Weatherwise

Volume 12, Number 3 June 1959

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

40th Anniversary Meeting

THE American Meteorological Society will celebrate its fortieth birthday with a special meeting at Boston from 19 to 22 January 1960 at which a large international attendance is expected. The Annual Business Meeting will also be held during these sessions at Boston instead of at the usual time in New York City. The regular AMS January meeting in New York City will be curtailed to a half-day joint session with the Institute of Aeronautical Sciences on 27 January.

Four important symposia will feature the first three days of the 40th Anniversary Meeting with invited papers from meteorologists who have made significant contributions in their fields. The general subjects are: The Nature and Causes of Upper Atmosphere Motions, Ocean-Atmosphere Interactions, The Use of Chemical Tracers for the Study of Atmospheric Circulations, and Fronts and Intense Vortices. The final day, 22 January, will be devoted to general sessions. Special social events are planned for each evening of the meetings. The program chairman, Prof. Jule Charney of M.I.T., may be addressed at the AMS headquarters.

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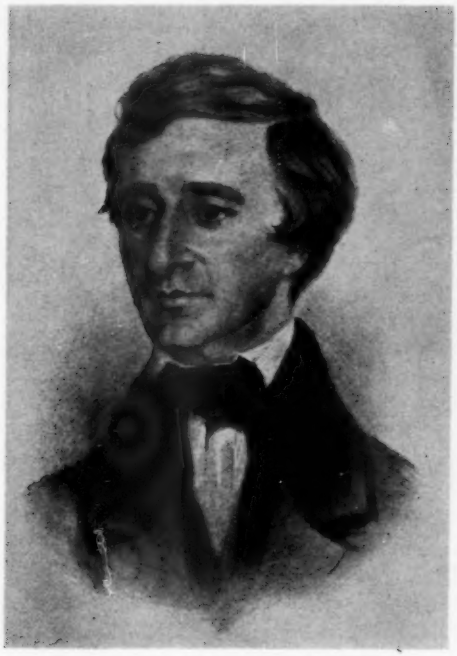
Front cover: Pilot obtaining flying weather information from automatic-continuous weather broadcast station, KWO 35, New York. Weather Bureau photo.

WEATHERWISE is published bimonthly for the American Meteorological Society. Office of publication, 3 Joy St., Boston 8, Mass. Subscription is $4.00 per year; add 50 cents for postage to Canada and all countries in the Pan-American Postal Union; add $1.00 for all other foreign countries. Subscription orders, claims for missing numbers, changes of address, and advertising correspondence should be addressed to the society at 3 Joy St., Boston 8, Mass. Editorial offices: Box 216, Princeton, N. J.



Henry David Thoreau, 1817–1862. (From the crayon drawing by Samuel Rowse in 1854. Courtesy of The Thoreau Society.)

Thoreau and New England's Weather

LAWRENCE WILLSON,
University of California,
Santa Barbara
Goleta, California

ONE who today enters the Concord Free Public Library in Concord, Massachusetts, and approaches the delivery desk will find immediately before him a volume of Henry Thoreau's published Journal, opened to the entry for the day of a century or more ago which corresponds to the day of his visit. Frequently that entry contains a succinct account of the weather in Concord on that fairly ancient day, and often some philosophical comment on it or on meteorological matters in general. "In keeping a journal of one's walks and thoughts," he wrote, "it seems to be worth the while to record those phenomena which are most interesting to us at the time. Such is the weather. It makes a material difference whether it is foul or fair." And he added, like a true Yankee, "I incline always [to] questions about the weather without thinking." Since the student of Thoreau has been traditionally incapable of avoiding the temptation to affix a label to him, in an effort to catch as much of his meaning as is possible in a phrase, we might consider briefly the justifications for calling him something like Yankee Weatherman, or Transcendental Meteorologist, or simply Thoreau the Weatherwise.

His friend and first biographer, William Ellery Channing, gave him the general label *Poet-Naturalist,* adding, almost parenthetically, in the words of Emerson, "He was a natural Stoic." A Professor Nichols, hewing to a finer line, carved for him the title of *stoico-epicurean adiaphorist,*[1] and so the game of labeling has gone. Thoreau is at once *a Greek turned transcendental economist;* a Cynic; *the Socrates of the American Attica; an ascetic of the Epicurean sect; a Yankee Diogenes; St. Simeon Stylites residing on a pillar;* and a member of the glorious company of John Woolman; George Fox; Mohammed; and *him of Nazareth.* He is a prophet and *a preacher of righteousness;* or, more exactly, a *prophet of Nature*—even *the Concord 'Deacon of Nature.'* He is *an American Rousseau,* as well as *the very antithesis* to Rousseau. He is the *Hermit of Walden, a romantic idealist,* the *friend of the Native, a small boy dream-*

[1] Quoted by Gilbert P. Coleman, "Thoreau and His Critics," *The Dial,* **40** (1 June 1906), 352.

Thoreau's Cove on Walden Pond in wintertime. Courtesy of Mrs. L. O. Anderson and the Concord Free Public Library.

ing of high adventure, that unique individual, half college graduate and half Algonquin, the Robinson Crusoe of Walden Pond, and many other things, some considerably less complimentary. James Russell Lowell called him *thus far the most remarkable* among *the pistillate plants kindled to fruitage by the Emersonian pollen.*

The various interests and activities of Thoreau offer their justification for these partial characterizations. Possibly the best clue to a final label was offered by a perhaps kinder and more understanding friend than Emerson, one whom Thoreau himself loved more dearly, Amos Bronson Alcott, who said of him:

> He, of all men, seems to be the native New-Englander, as much so as the oak, the granite ledge, our best sample of an indigenous American, untouched by the Old Country, unless he came down from Thor, the Northman.[2]

"He was a plain New England man, who sighed neither for old England nor for Greece and Rome," said George William Curtis, and Henry Canby has emphasized that he was *first of all a New Englander,* a *stiff-backed, prickly, power-charged New Englander.* "Here is my Italy, my heaven, my New England," Thoreau rhapsodized.

> Seen through this November sky, these sands are dear to me, worth all the gold of California. . . . Dear to me to lie in, this sand; fit to preserve the bones of a race for thousands of years to come. And this is my home, my native soil; and I am a New-Englander.

His highest praise for the style of Carlyle's writing was that it suggested a New England landscape; and he could be annoyed, after the fashion of every good Yankee, that it was impossible to find pie in Montreal.

Thoreau's provincialism, such as it was, is inestimably reduced in effect, however, when one considers that its point and purpose were to study and understand New England so that he could address it in terms which it could comprehend and so that he could raise its standard of life, perchance by lowering its standard of living. He was a New Englander

[2] "The Forester," *The Atlantic Monthly,* 9 (April 1862), 443.

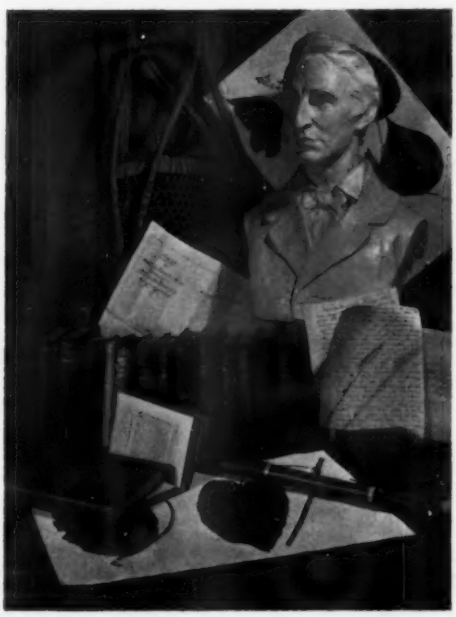
because he was born in New England; he remained a New Englander because here was soil into which he could sink his spade and know that there was no doubt of its existence. He addressed himself to New England, but he remarked at the outset, "Our sympathies are not confined to Massachusetts."

As one who sought to address New England, he made it a point to know his section as thoroughly as books, occasional travel to distant points, and constant observation could teach it to him. He read the available histories, both English and French, and the records, both accurate and fanciful, of the Indians, with a view to establish the exact facts of history, geography, the origin of place names, the economics of an older, simpler, more "natural" way of living. He read the various chronicles of natural science, studying the influence of plants and animals on the lives of New Englanders, white and red. He sought to discover, by the multiplication of the evidences of it, that nature and men were in perfect harmony if they chose to be. As an aspect of his major concern with nature was the typical interest of his section in the weather.

Inserted into one of his "Fact-Books," preserved in the Berg Collection of the New York Public Library under the title "Extracts, mostly upon Natural History," are a series of references to the climate of New England, principally of Boston and vicinity, drawn in large part from *The American Almanac and Repository of Useful Knowledge* for the years between 1850 and 1858. His interest was directed, according to these notes, to the temperatures, "Max—min & mean," during these years, in Massachusetts towns; to figures on the "Extremes" of snow and rain there and "Frosts Snows &c in Hiram, Me . . . from 1817 to 1849"; to the "Force of winds—Quality of clouds & depth of rain" in Cambridge; to the "Flowering of Peach Cherry & Apple in Cambridge . . . & other places." Inserted also is a sheet from an almanac, discussing such aspects of climate in Boston as ". . . The Mean Heat . . . For Ten Years (nearly). . . . The Quantity of Rain and Melted Snow. . . . Snow-Storms for Sixteen Years," etc. There is a memorandum of Jonathan P. Hall's "Register of the Thermometer for 36 Years, from 1821 to 1856, to which is added the Quantity of Rain falling in Boston . . . for 34 Years, from 1823 to 1856" in the *Memoirs of the American Academy of Arts and Sciences* for 1858. Later in the book he recorded eight pages of details of various aspects of climate from Lorin Blodget's *Climatology of the United States, and of the Temperate Latitudes of the North-American Continent*, a book to which he refers in his Journal for 6 March 1861.[3]

I have never known a genuine Yankee who did not start the day and finish it by glancing first at the thermometer, next at the sky, and then making a prediction. New England's weather has helped to make her people what they are; they have been forced to watch it constantly and to understand it, insofar as it is understandable, from the day when the Pilgrims, landing on the cold and wind-swept shore of Cape Cod, caught—many of them—the coughs and colds which led them to their deaths during the first winter. Thoreau noted the record in Mourt's

[3] I quote from the Fact-Book by permission of the Curator of the Berg Collection.



A collection of Thoreau's possessions and productions with a bust made from his death mask. Courtesy of *Fortune* and the Concord Free Public Library.

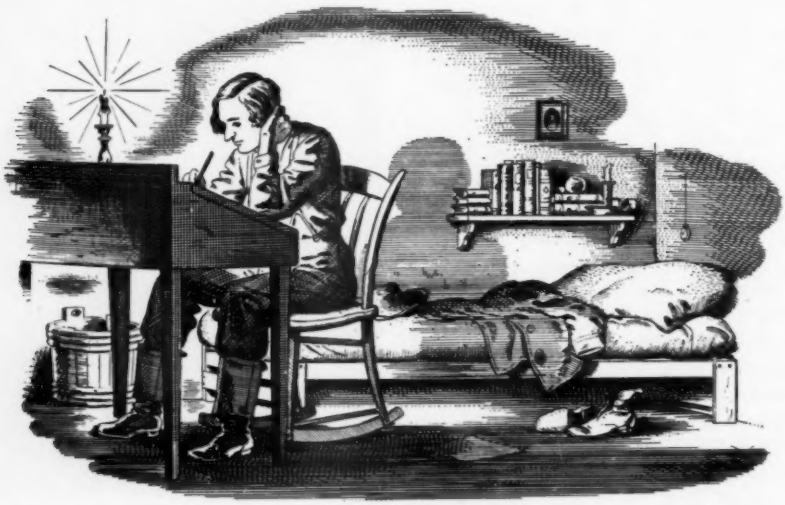
Relation and was well aware of the principle involved. The weather is the voice and breath of nature; and by a contemplation of it, both in the historical past and the historical present where he securely dwelt, he could learn much, not only about the course of New England's history but about the demonstrated necessity of correspondence. Men *had* to consider the elements. Thoreau was prepared perfectly to understand as he read about the constant struggle toward correspondence. He put down William Bradford's description of the difficulties caused among Plymouth's first fishermen by freezing spray, adding, "Nature has not changed one iota." Nature could not change, being the physical manifestation of that fundamental law which he sought to discern.

He consulted the record to learn about the history of the weather in New England and to study its effect upon human life there. When he read John Josselyn and "Old" Johnson on the history of Concord, he copied that portion of their commentary which had to do with location and natural resources and the weather. He was especially pleased when a part of historical weather repeated itself for him, and when it did not—under the exactly prescribed conditions—he was doubtful of the record. He conducted researches, for example, to discover what the weather had been in April 1775, because he doubted the legend that "the grain was waving in the fields and the apple trees were in blossom" when the embattled farmers gathered. On 14 April 1852 he raised the question in his Journal:

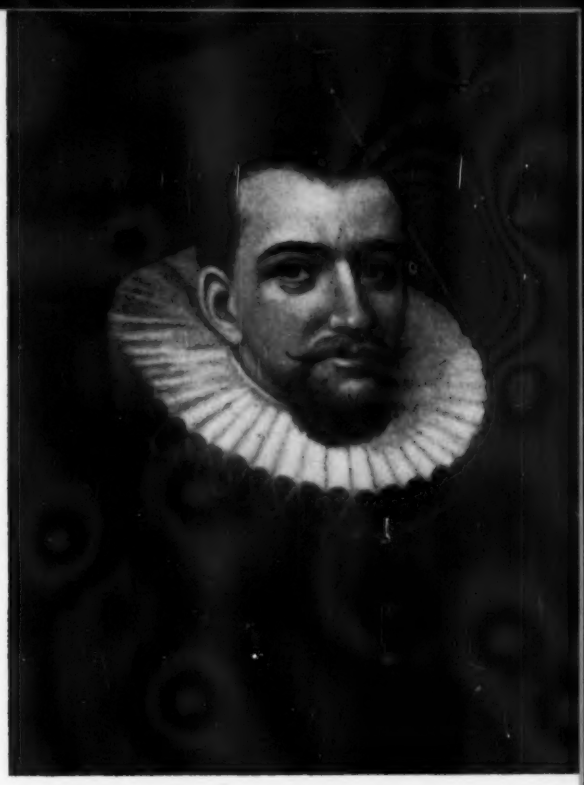
> Can we believe [the story] when beholding this landscape, with only a few buds visibly swollen on the trees and the ground covered eight inches deep with snow . . . ?

But he was willing to accept the story on the testimony of his grandmother, "that she carried ripe cherries from Weston to her brother in Concord Jail the 17th of June the same year." He added, still doubtful, "It is probably true, what E. Wood . . . says, that the grain was just beginning to wave, and the apple blossoms beginning to expand." Four years later, on 2 June 1856, returning with Emerson from Perez Blood's auction, he considered the subject again, with the cryptic notation: "See Camilla on rye, undulating light and shade; not 19th of April." On 25 April 1859 he got "the first decided impression of greenness beginning to prevail" and observed, "Even the grass begins to wave, in the 19th-of-April fashion." In the next year,

(*Continued on page 118*)



This drawing of Thoreau at work was made by Paul Hawthorne directly from furniture in the Thoreau Room of the Concord Antiquarian Society House. Courtesy of the Old Colony Trust Company of Boston and the Concord Free Public Library.



Henry Hudson, English navigator and explorer. Died 1611. Bettmann Archive.

New York's First Weatherman

DAVID M. LUDLUM

THOSE who have the temerity to state historical "firsts" must develop a defensive hide, equally as tough as that worn by those who have the courage to attempt a daily weather forecast. The public considers both fair game for immediate attack.

Somewhat sharing the above duality and thus cloaked with a double-thick hide, I would like to nominate Robert Juet of Limehouse, England, for the designation of "New York's First Weatherman." Contemporary accounts tell us that Juet was a close associate of Henry Hudson: The Navigator, serving as first mate on the second and fourth voyages and in some undetermined capacity a crew member on the third voyage in 1609 to our Middle Atlantic and New England shores. Most fortunate for historians and weathermen, Juet had the leisure to note the surroundings and to describe the events of that historic journey.[1] It appears that Hudson, himself, although his logs of other voyages are extant, left no personal record of the explorations of the great river which bears his name.

Now it is quite well established that Hudson was not the first European to view or visit

[1] *The Third Voyage of Master Henry Hudson, toward Nova Zembla, and at his returne, his passing from Farre Islands to New-Foundland, and along to Fortie-Foure Degrees and Ten Minutes, and thence to Cape Cod, and so to Thirtie-Three Degrees; and along the Coast to the Northward, to Fortie-Two Degrees and A Halfe, and up the River neere to Forty-Three Degrees.*

New York Bay. Certainly, Verazzano, the Italian sailing for the King of France, described a harbor most surely that of New York about 1 May 1524; and the Portuguese Estevan Gomez, under the employ of the Spanish monarch, appeared on the New York scene a few months later. More shadowy claims have come from the backers of John Cabot, Leif Ericson, the Welsh traders, Irish Monks, the Phoenicians, and the Lost Tribes of Israel, but none of these worthies has left a written record of entering and exploring the present Hudson River.

I am also mindful that a small group of die-hard Jerseyites have not yet reconciled themselves to the loss of Staten Island to New York some three hundred years ago, and with some justice they might claim Juet as "New Jersey's First Weatherman," since the early action of the following chronicle took place along the Jersey shore of the Lower Bay and on the disputed island. The bulk of the story, however, deals with the present Empire State, so with the above preliminary apologies stated, I shall stand by my first title.

Gladly, then, I return to Henry Hudson and Juet's detailed account of conditions, meteorological and otherwise, which his men found on their month's sojourn along the banks of the majestic river in September 1609. It is very timely that honor be done to New York's First Weatherman in this year and month since it marks the commencement of the 350th anniversary celebration of the discovery and exploration of the Hudson River from the south by a Dutch-English group and also of Lake Champlain from the north by the French under Samuel de Champlain.

In the following condensed chronicle are extracted all references to the weather in the descriptive diary of Juet.[2] It appears that September 1609 enjoyed a persistent anticyclonic regime with weather mainly "faire and hot" for most of the month, but at the commencement of October a severe northeaster, possibly the fringe of a hurricane, swept the area around Manhattan Island, giving the Navigator some anxious moments as the winds backed around with the storm's passage.

Since the dates given are Old Style, one must add ten days to each date so as to be comparable with our present calendar and season. The approximate location of the Half Moon, though subject to much scholarly debate, is given in italics for the geographic orientation of the reader.

The first of September, faire weather, the wind variable betweene east and south; we steered away north north-west. (*Off New Jersey*)

The second, in the morning, close weather, the winde at south in the morning; from twelve until two of the clocke we steered north north-west. . . . At five of the clocke we anchored, being little winde, and rode in eight fathoms of water; the night was faire. (*Near Ambrose Light*)

The third, the morning mystie, untill ten of the clocke; then it cleered, and the wind came to the south-southeast, so wee weighed and stood to the northward. (*Entering New York Bay*)

The fourth, in the morning, as soone as the day was light, wee saw that it was good riding farther up. . . . At night the wind blew hard at the north-west, and our anchor came home, and wee drove on shoare, but tooke no hurt, thanked bee God, for the ground is soft sand and oze. (*Off Staten Island*)

The fifth in the morning, as soone as the day was light, the wind ceased. . . .

The sixth, in the morning, was faire weather. . . . The night came on, and it began to rayne. . . .

The seventh, was faire. . . .

The eighth, was very faire weather. . . .

The ninth, faire weather.

The tenth, faire weather. . . . (*In the Narrows*)

The eleventh was faire and very hot weather . . . the wind at south south-west, little winde.

The twelfth, very faire and hot . . . the winde being variable between north and the northwest.

[2] *Henry Hudson The Navigator. The Original Documents in which his career is recorded. Collected, Partly Translated, and Annotated, with an introduction* by George Michael Asher, LL.D. London: Printed for the Hakluyt Society, 1860 (No. 27), p. 45–93.

The thirteenth, faire weather, the wind northerly. (*Off Manhattan Island*)

The fourteenth, in the morning, being very faire weather, the wind south-east. . . . (*Near West Point*)

The fifteenth, in the morning, was misty, untill the sunne arose: then it cleered.

The sixteenth, faire and very hot weather. (*Near Hudson*)

The seventeenth, faire sun-shining weather, and very hot.

The eighteenth, in the morning, was faire weather, and we rode still. (*Near Albany*)

The twentieth, in the morning, was faire weather.

The one and twentieth was faire weather, and the wind all southerly. . . .

The two and twentieth was faire weather. . . . This night, at ten of the clocke, our boat returned in a showre of rain from sounding of the river. (*Just beyond Troy?*)

The three and twentieth, faire weather . . . and had little wind. . . . Then wee had a little gale of wind at the west. (*Start southward*)

The foure and twentieth was faire weather: the winde at north-west. . . . (*Near Hudson*)

The five and twentieth was faire weather, and the wind at south a stiff gale. (*Near Catskill*)

The sixe and twentieth was faire weather, and the wind at south a stiffe gale.

The seven and twentieth, in the morning, was faire weather, but much wind at the north. . . . At five of the clocke in the afternoone, the wind came to the south south-west. (*Near Red Hook*)

The eighth and twentieth, being faire weather. . . . (*Near Esopus*)

The nine and twentieth was drie close weather; the wind at south, and south and by west . . . because the high land hath many points, and a narrow channell, and hath manie eddie winds. (*Near Newburgh*)

The thirtieth was faire weather, and the wind at south-east, a stiffe gale betweene the mountaynes.

The first of October, faire weather, the wind variable betweene the west and the north . . . then it fell calme. . . .

The second, faire weather. At break of day wee weighed, the wind being at north-west . . . but had much wind and raine. (*Near Ft. Lee*)

The third, was very stormie; the wind at east north-east. In the morning, in a gust of wind and raine, our anchor came home, and we drove on ground, but it was ozie. Then as we were about to have out an anchor, the wind came to the north north-west and drove us off againe. Then we shot an anchor, and let it fall in foure fathomes water, and weighed the other. Wee had much wind and raine, with thicke weather; so we rode still all night. (*Near Hoboken, opposite Manhattan*)

The fourth, was faire weather, and the wind at north north-west; wee weighed and came out of the river, into which we had runne so farre. . . . And by twelve of the clocke we were cleer of all the inlet. (*Past Sandy Hook into the Atlantic*)

New York's First Weathership, the *Half Moon*, in which Henry Hudson explored the Hudson River region. Painting by H. J. Kohler in the N. Y. Historical Society. Bettmann Archive.

Weather Radio Broadcasts

Joint Authorship by Sections of the Forecasts and Synoptic Reports Division, U. S. Weather Bureau

FREQUENT weather broadcasts are made every day over thousands of radio and TV stations throughout the country. Most familiar to the general public are those heard over the more popular AM and FM frequency channels of local commercial stations. For the average user, these reports are sufficient to answer his questions as to whether to take a raincoat to work, to call out a working crew for an outside construction job, or to continue plans for an out-of-doors picnic.

Less familiar, and entirely unknown to many, are special weather broadcasts made over low or high radio frequencies and disseminated for the use of pilots in the air and mariners at sea. Slanted to meet the needs of such groups, these broadcasts often have a wider area coverage and give much more in the way of current weather data than do the general weather broadcasts. For the amateur weatherman who enjoys looking into more of the specifics and watching developments on an up-to-the-hour basis, the aviation broadcasts in particular provide much helpful information. With the proper radio receiver, it is possible for one to relax comfortably at home while listening to these broadcasts, copy a select group of reports in the area, analyze them, and learn of special weather advisories for airmen and mariners.

These special broadcasts of Weather Bureau reports, advisories, and forecasts are made over radio communication facilities of the Federal Aviation Agency and the U. S. Coast Guard. Though some of the broadcasts are transmitted in code, there is a considerable variety of plain language broadcasts available in almost every locality.

Although these services are designed specifically for airmen and mariners, they are coming into increasing use by outdoor people, boatmen, and summer camp operators. Rightly

Air Traffic Control Specialist making a recording for Continuous Flying Weather Broadcasts on Washington L/MF Radio Range. Photo courtesy U. S. Weather Bureau.

so!—how many hikers would have delayed breaking camp, how many sailboaters would not have hoisted sail, or how many summer camps would have altered the day's program if they had known a squall line with heavy thunderstorms was due in a few hours? Because of the popularity of the aviation broadcasts, a number of manufacturers of portable radios have added a 200–400 kilocycle band to the standard broadcast band on their transistor line of battery-operated portables. These radios are advertised mostly in flying magazines, but alert and safety-minded outdoor people are finding them a very useful item to own. Perhaps some day soon manufacturers will add the 200–400 kilocycle band to their automobile radio products.

Scheduled Aviation Weather Broadcasts

Scheduled aviation weather broadcasts are made twice each hour over Federal Aviation Agency (FAA) radio range stations having associated voice facilities. At 15 minutes past each hour a voice broadcast of selected current weather reports from 8 to 12 locations within 150 miles of the broadcast station is made. The other broadcast, at 45 minutes past each hour, includes 8 to 12 reports of weather conditions at the more important cities or airports within about 400 miles of the broadcasting station.

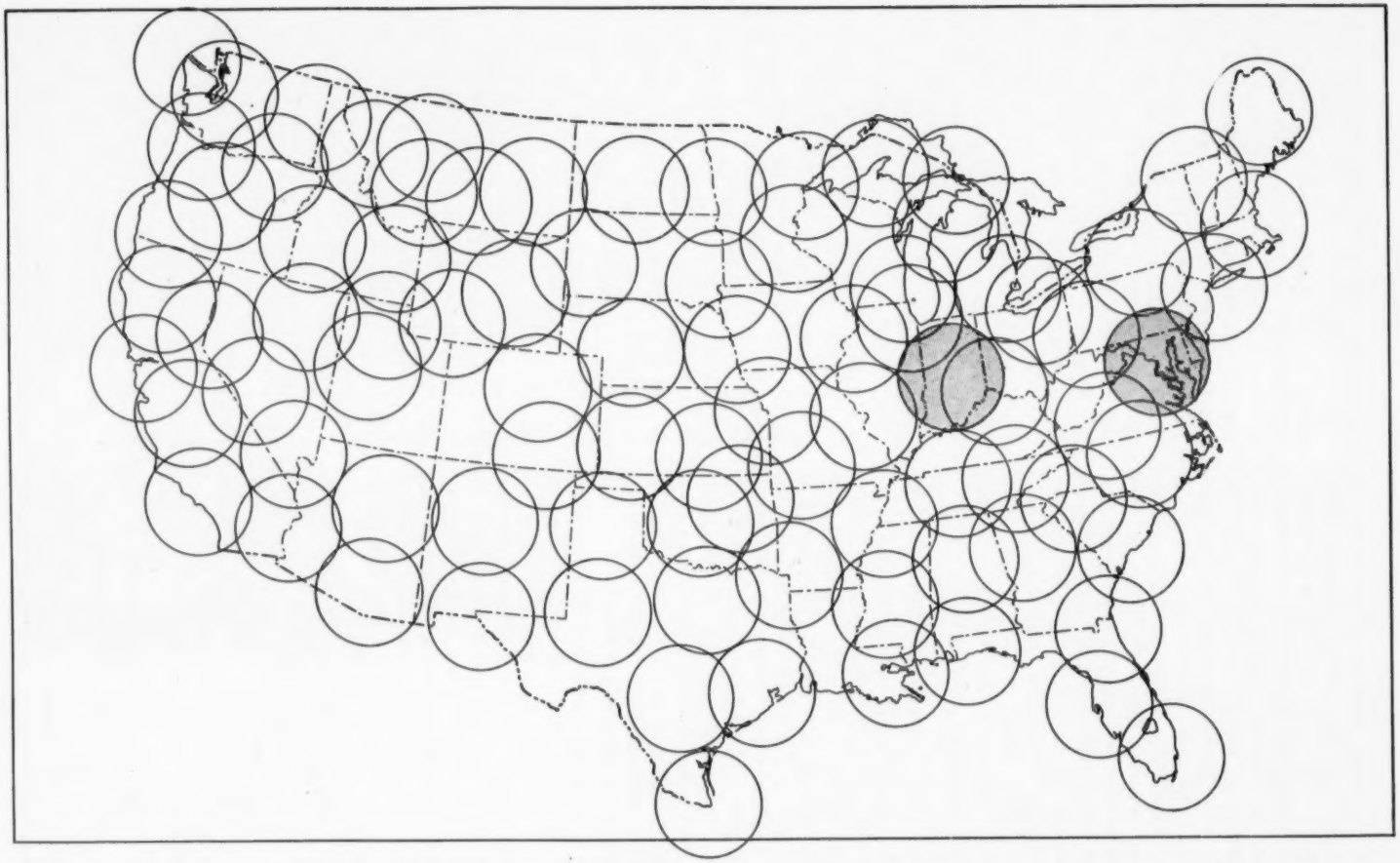
Local upper-air winds up to 20,000 feet are added four times daily (6-hour intervals) to the first 45-minute broadcast after they become available. When flash advisories are issued to provide airmen in flight with advance notices of adverse weather developments or trends that are potentially hazardous, such as squall lines, thunderstorms, fog, icing and turbulence, they also become a part of the broadcast.

The radio facilities used for these broadcasts are low/medium frequency (L/MF) ranges and very high frequency omnidirectional ranges (VOR's). They are located at many airports throughout the country. There is one or more of these facilities in each local reception area. Broadcast bands for the L/MF ranges are from 200 to 400 kilocycles and those for the VOR's are around 108 to 118 megacycles. The actual transmitting frequencies of all of individual ranges can be found in the Airman's Guide, on Sectional Aeronautical Charts, or, in the cases of broadcasts relating to overseas flights, in the International Flight Information Manual. Specific details about ordering these publications are included at the end of this article. However, it is not actually necessary to purchase these materials to determine the broadcasts available in your own area. If you wish to locate and record the frequencies of the broadcasting facilities in your area, make a simple chart like the one shown in figure 1. At fifteen minutes past any hour, tune your radio to 200 kilocycles. Move the dial towards higher frequencies until you hear a weather broadcast. The identification of the broadcasting station will be given at the end of the broadcast—about three minutes duration—and you can then record the station identifier and the frequency. Wait until forty-five minutes past the hour and begin moving the dial upward from the frequency at which the first station was heard. When you hear another broadcast you can record the frequency and identification of this station. You can thus cover the entire band between 200 and 400 kilocycles in a few hours and have a record of the L/MF range weather broadcasts receivable in your locality.

Or, if you are an impatient type and want to play with a few dots and dashes, just begin the operation at any time. Actually, you can spot the frequencies to which to tune for weather broadcasts between voice broadcast times by listening for the coded navigational signals—A(·–) or N(–·) or "on course" tone (——) and the three letter station designator given every minute, such as DCA (–·· –·–· ·–) for Washington, D. C. In the process you will also find a few position markers with two- or three-letter identifiers which will not have voice broadcasts, but this distinction can be made in a very short time.

Evening or early morning hours are usually best for reception. If your radio is portable and has a built-in antenna, it is probably also highly directional. In this event your station-hunting procedure should include rotation of the receiver up to 180°. Unless you have a very sensitive receiver and a good antenna don't expect to bring in stations beyond about 50 miles. With a sensitive receiver and good antenna exposure, 100 miles would be very good.

Similar steps can be followed to determine whether any VOR weather broadcasts can be



Circles represent the areas to be covered by the 88 Continuous Aviation Broadcast System stations on 200–400 kc. which will be in full operation by the end of 1960. Shading indicates areas already operating.

L/MF Aviation Weather Broadcasts

Station	Identifier			Frequency (kc)
Baltimore, Md.	B -...	A .-	L .-..	257
Washington, D. C.	D -..	C -.-.	A .-	332 (continuous)
Front Royal, Va.	F ..-.	R .-.	R .-.	359 (voice from Martinsburg)
Andrews AFB, Md.	A .-	D -..	W .--	379
Gordonsville, Va.	G --.	V ...-	E .	388

Fig. 1. Sample chart for recording area facilities within listening range.

received in the area. However, don't expect to pick up any more than one because very high frequencies (VHF) are such that at ground level they can be received only at very short distances, or within line of sight, from the transmitting facility.

Continuous Aviation Broadcasts

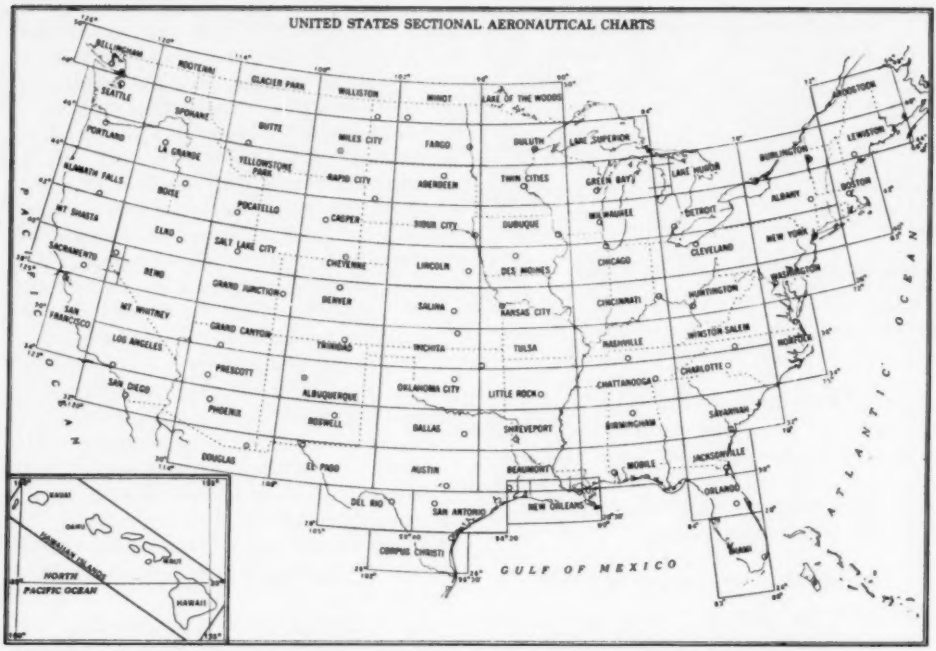
Probably the most convenient and useful of all types of current weather information services are the continuous voice broadcasts for aviation. The fact that they are immediately accessible and self-repeating has made them especially popular with pilots and will undoubtedly make them equally desirable to other users. Such broadcasts were begun by the New York and Chicago aviation weather forecast centers of the Weather Bureau early in the 1950's. These stations are still in operation and the broadcasts can be picked up in these areas between 6 a.m. and 6 p.m. by tuning to a frequency of 162.55 megacycles. These broadcasts are receivable only within 35 miles of the New York Battery and the Chicago Loop, since they are line of sight reception. These broadcasts will be converted from aviation weather service to weather service for boating and harbor operations when the continuous L/MF broadcasts described below are begun about September 1959.

Following the success of the continuous broadcasts on 162.55 megacycles the Weather Bureau and FAA (then CAA) began joint plans for continuous aviation weather on L/MF facilities. The first such broadcast was conducted by the Weather Bureau at Washington, D. C., using the FAA L/MF radio range at Arcola, Virginia, as the outlet. This began in October 1954 but was discontinued in August 1958 when the Arcola radio range was dismantled to make room for constructing the new Chantilly jet airport. The continuous broadcast has now been shifted to the DCA-Washington radio facility. In May 1958 a second continuous L/MF weather broadcast was started on the Indianapolis radio facility. These broadcasts require special transcribing equipment to make them self-repeating. Plans are well along to establish a nationwide system of 88 such broadcasts by the end of 1960. Locations of these are shown in figure 4.

L/MF radio facilities have a listening radius of about 125 miles (with good receiving antenna) and the weather information included in the broadcast covers an area roughly 250 miles in radius. Reports are brought up-to-date each hour and intervening reports of significant changes are inserted in the broadcast as soon as possible after the change occurs. Forecasts and warnings are also kept current.

Each broadcast includes the following: station identification, forecast and/or advisories (warnings), winds aloft forecast, pilot weather reports, and local weather report followed by reports from eight additional airports. Forecasts are given in "plain language" and reports are spoken in a standard order. An actual forecast and a report are quoted below to illustrate the style.

> Forecast—"This is Washington Radio broadcasting aviation weather and notice to airmen information. Warnings to small aircraft are in effect over all routes out of Washington. A storm centered just east of the Virginia capes is deepening rapidly. It will move northeast or north-northeast about 30 knots. In the Washington-Baltimore area and along routes to Norfolk and Raleigh there will be rain possibly mixed with snow and fog with ceilings around 1,000 feet and visibilities near 2 miles but occasionally down to about 500 feet and 1 mile improving in the Raleigh-Norfolk area to broken clouds at 2,000 to 4,000 feet by late afternoon. Along the routes to New York City, Pittsburgh, and Knoxville ceilings 1,000 to 3,000 feet and visibilities 2 to 4 miles in light snow, but ridges will be obscured all day with tops above 10,000 gradually lowering this afternoon. Occa-



Guide to the location of United States Aeronautical Charts which may be obtained from the U. S. Coast and Geodetic Survey.

sionally heavy mixed clear and rime icing will occur along the route to New York City with mostly light rime icing over other routes."

Report—"Washington—Measured ceiling 900 feet broken clouds, 1500 feet overcast, visibility 2 miles, light rain, fog, temperature 39, dew point 38, wind northwest 11, altimeter setting 29.71. Precision approach radar out of service."

Marine Weather Broadcasts

Residents in the Great Lakes and Atlantic, Gulf, and Pacific coastal areas will also be interested in the weather reports, forecasts, and warnings broadcast to merchant shipping, fishing fleets, or pleasure craft.

District Forecast Centers of the Weather Bureau issue warnings any time developing weather conditions are expected to affect the safety of marine navigation. These forecasts and warnings, including weather reports, are broadcast both by AM and FM radio and TV stations, as well as by Coast Guard and commercial marine radio-telephone and radio-telegraph stations located along the U. S. seacoasts and the Great Lakes. Whenever warnings are issued, they are broadcast by these stations promptly upon receipt of the message and at intervals thereafter.

Detailed information on times of broadcasts, radio frequencies of marine broadcast stations, specific types of warnings issued, and visual display signals used in connection with the warnings is available on Coastal Warning Facilities Chart series published annually by the Weather Bureau. Areas covered by each chart are included in a reference list at the end of this article.

There is, then, available in broadcast form an extremely large volume and variety of weather data. The amateur weatherman can obtain his information from commercial broadcasts, aviation broadcasts, or marine broadcasts by selecting and following those which he finds to be most interesting or useful. He can use these data to keep himself informed of the detailed weather conditions in his particular area, and, if he so desires, can construct rough charts or prepare a forecast of his own.

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Coastal Warning Facilities Chart Series. Issued annually by U. S. Department of Commerce, Weather Bureau. Price 5 cents each. Printed and sold by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Series titles:

Canada Border to Eureka, California
Eureka, California to Point Conception, California
Point Conception, California to Mexican Border
Eastport, Maine to Montauk Point, N. Y.
Montauk Point, N. Y. to Manasquan, N. J.
Manasquan, N. J. to Cape Hatteras, N. C., and Chesapeake Bay
Cape Hatteras, N. C., to Brunswick, Georgia
Eastern Florida
Morgan City, Louisiana to Appalachicola, Florida
Morgan City, Louisiana to Brownsville, Texas
Great Lakes: Superior and Michigan
Great Lakes: Huron, Erie, and Ontario

International Flight Information Manual. Issued annually by the Federal Aviation Agency (formerly Civil Aeronautics Administration). Price 60 cents. Printed and sold by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Sectional Aeronautical Charts (for the United States). Issued by U. S. Coast and Geodetic Survey. Price 25 cents each. Orders are placed through Director, Coast and Geodetic Survey, U. S. Department of Commerce, Washington 25, D. C.

Radio Receivers

Most standard American broadcast receivers tune only to the 540–1620 kc. band and will not pick-up the low frequencies band from 200–400 kc. on which the FAA radio range stations broadcast weather information. Some sets of European manufacture do contain this band since it is a channel for regular broadcasts there.

One must turn to specialized sets which were designed to meet the requirements of either aviation or marine users. During World War II a large number of small aircraft receivers were manufactured with the 200–400 kc. band. Many of these have found their way into surplus channels and may still be purchased for $10–$15 from large radio supply houses. They usually operate on 28 volts and thus require the additional purchase of a surplus dynamotor for operation on 115v. house current (additional cost $10–$15). Consult the pages of radio "ham" magazines for names of such supply houses.

Two "Do-It-Yourself" kits are marketed by the Heath Company of Benton Harbor. The Heathkit Transistor Radio Navigator, model DF-2, contains two bands, 200–400 kc. and 540–1620 kc., and also a directional loop antenna (Price $69.95). Another low-cost kit of the Heath Company is the Ocean-Hopper Kit which may be supplied with a special coil for reception on the 200–400 kc. band.

Several manufacturers have recently added the 200–400 kc. band to their small transistor portables. The Weatherman Slim Six (L. T. Labs, 113 Pine St., Waukegan, Illinois) has six transistors and operates on four penlight cells (Price $69.95). The Motorola Weatherama has six transistors and four penlight cells (List $79.95). The Zenith Royal 760 Navigator has eight transistors and six small "C" batteries (List $99.95). The Zenith Company also includes the weather band on some models of their famous Trans-Oceanic Portable Receiver (List $259.95).

Among receivers designed for marine use, the National Radio Company has introduced their NC-66 which has continuous tuning from 150 kc. to 23 mc. (List $129.95). This covers the FAA ranges, standard broadcasts, marine and Coast Guard reports, and several international aviation bands. With the addition of a RFD-66 Direction Finder (Price $39.95), the set becomes a navigation device. Some of the more expensive "ham" sets manufactured by Hallicrafter, Hamerlund, National, etc. also contain a 200–400 kc. band.

A word of caution should be added here. The present FAA radio ranges are low power transmitters and have a dependable speaker-volume reception of about 50 miles in daytime. Radio waves in this band are directional, and your antenna must be properly aligned for maximum signal. A correctly directed antenna and a ground connection may increase audibility to 125 miles under good conditions. Range and audibility increase greatly after sundown. Unfortunately, atmospheric electricity causes much annoyance on this band. Often, when the information is needed most, as during a thunderstorm, the signals are almost unreadable due to crackling static.

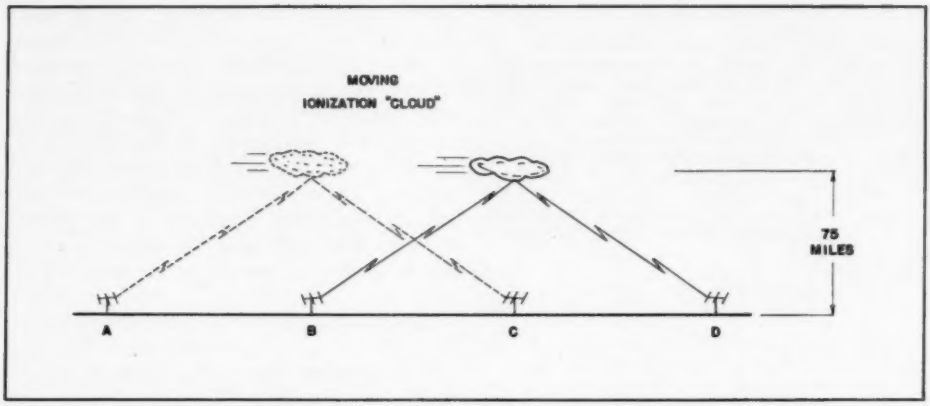

FIG. 1. The presence of a patch of ionization permits communication between stations B and D and not between other stations. Several hours later the path between A and C is open, indicating a movement of the reflecting "cloud."

Meteorology and Amateur Radio

ROBERT T. DUQUET, *Department of Meteorology, Pennsylvania State University*

ALMOST daily we hear of the advances that are occurring in science on the occasion of the International Geophysical Year. This world-wide exchange of information between teams of ultra-specialists concentrates the efforts and the resources of entire nations on the task of solving modern scientific problems. The description of most I.G.Y. projects leaves the impression that there exist nearly insurmountable barriers to the accumulation of any new scientific knowledge; if an I.G.Y. is necessary to the advancement of science, there must certainly be left nothing of significance for the curious non-specialist to contribute. Happily, this is not the case.

AMATEURS AND MODERN SCIENCE

Some examples will illustrate the type of contributions to science that are currently being made by amateurs. In ornithology, thousands of non-professional bird-watchers accumulate yearly more information than can be gathered at firsthand by professionals in a decade. The enterprise of some of these amateurs, in banding birds and in recording the passage or habits of the innumerable species, provides a wealth of data that cannot be duplicated by any another means. The quality of these observations is frequently amazingly good. Even an imprisoned man, completely untrained and with nothing but the simplest self-made equipment, has been able to make remarkable contributions to bird pathology (1). A second example is more impressive in as much as it concerns a field in which vast sums of money are spent by institution- or government-sponsored professionals: amateur astronomers carry out tasks which would not justify the use of high-powered research instruments but which do contribute to our store of knowledge. Among these tasks are the observation of variable stars and the changing features of closer planets. The recorded data of amateur sky-watchers has been invaluable to Hess in developing a Martian meteorology (2). Even

in terrestrial meteorology, where an obvious practical importance has prompted the establishment of hundreds of official observing stations, the contribution of cooperative observers is greatly appreciated and, in many cases, is the sine-qua-non of detailed climatological studies.

Amateur Radio Operators

"Ham" radio operators appeared in the very infancy of radio technology. Their availability as ready trained technicians during World War I was sufficiently valuable to justify their continued activity despite the growing demands, even then, for radio frequency assignments. Wavelengths of 200 meters and shorter, which were then considered useless, was the logical allocation. A federal licensing procedure was established which guaranteed a minimum technical competence in order to assure non-interference with other radio uses. The exploration and development of these wave lengths, including some famous trans-Atlantic tests (3), was an outstanding amateur achievement. As the value of the "useless" wave lengths became apparent, amateurs were mostly displaced by commercial interests, but they had amply proven their worth.

The association between meteorology and amateur radio began as early as 1934 when Ross Hull (4) discovered the effect of atmospheric conditions on VHF propagation. In that year amateur communication on a repeated basis was established at 5 meters wave lengths between Hartford and Boston. This distance exceeds line-of-sight, then the accepted and theoretically-confirmed limit. In a first-class piece of research, using aircraft soundings provided by Dr. Brooks of the Blue Hill Observatory, Hull (5) established the relationship between tropospheric inversions and abnormally long propagation paths.

There are, at present, over 180,000 licensed amateurs in the United States alone. Most of these are more entranced by the communications aspect of radio than by its use as a scientific instrument; their main usefulness to meteorology lies in their service during "disaster" weather. An example of this type of supplementary communication network is the Weather Amateur Radio Network which was featured in the August 1953 issue of *Weatherwise* (6). But the rapid advance of the science of radio has not left the amateur behind. The threat of extinction because of interference with other radio uses (e.g. television) has forced a continued improvement in the technical quality of all the survivors and is reflected in the higher standards of the license requirements. The most important hams from our point of view are those who, because of a strong personal interest, are continuing scientific experiments and observations. Many of these activities are of meteorological interest.

Meteorology and Amateur Radio Activities

Since balloon-borne sounding equipment does not rise much above 20 miles or so, our knowledge of atmospheric constituents, of tidal motions, and of seasonal and daily variations in the winds at altitudes above 20 miles is based largely on indirect means of measurement. One of these is radio. From altitudes of 35 to about 200 miles there are several layers of ionization which reflect, absorb, or scatter radio-waves. Here is a field where the amateur radio operators can contribute to meteorology.

A good example is the study of "sporadic E" (E_s) cloud drift. Dense patches of ionization appear at frequent but irregular intervals at altitudes of about 75 miles. A layer of ionization is usually present just below this region, but the local nature and the strength of ionization distinguish these patches (or "clouds") from the normal background. The clouds appear most frequently in the spring in middle latitudes but are present in almost equal number in all seasons near the equator. Radio waves of about 6 meters wave length are reflected by these clouds, a fact which attracted the interest of radio amateurs. A Geophysics Research Directorate project was set up in which the many reports of abnormal 6-meter communication logged by amateurs scattered throughout the United States were collected and analyzed. After those reports

which were isolated cases or which could be attributed to other causes were eliminated, there emerged a pattern in the appearance and disappearance of abnormal signal paths. The mechanisms are illustrated in figure 1. The results, reported by Gerson (7), showed that frequently the clouds drift intact across the country with speeds of about 250 miles per hour. Seasonal variations in direction and speed of the motion which are attributed to a high-level wind were also indicated. To quote Gerson (7): "Very little is known regarding that curious phenomenon known as sporadic E. The mechanisms regarding its genesis, movement and apparent dissipation are completely unknown." And again, "Although the ideal E_s reporting system has never been established, it has been approximated over North America by the voluntary cooperation of large numbers of amateur radio operators."

The same type of amateur cooperation was organized by O. G. Villard (8) in connection with operation "Smoke-Puff." In this experiment, a quantity of nitric oxide gas was sent aloft in an Aerobee rocket and was released in the vicinity of the E layer of the ionosphere. An artificial ion cloud was produced. The experiment was designed to confirm a theory of the action of a particular frequency of sun-light (known as Lyman Alpha) on the atmosphere. Professional radar equipment was used to study the puff but additional invaluable data were obtained from the amateurs. Since the ion concentration to be produced could not be predicted with certainty, amateurs were instructed to try to reflect radio waves of from 20 to 2 meters length from the puff. The fact that only the shorter wave lengths were reflected gave information on the ion concentration. The rate of diffusion of the puff could also be determined from the change in ion concentration and its motion could be estimated from the change in signal path which was caused by the puff.

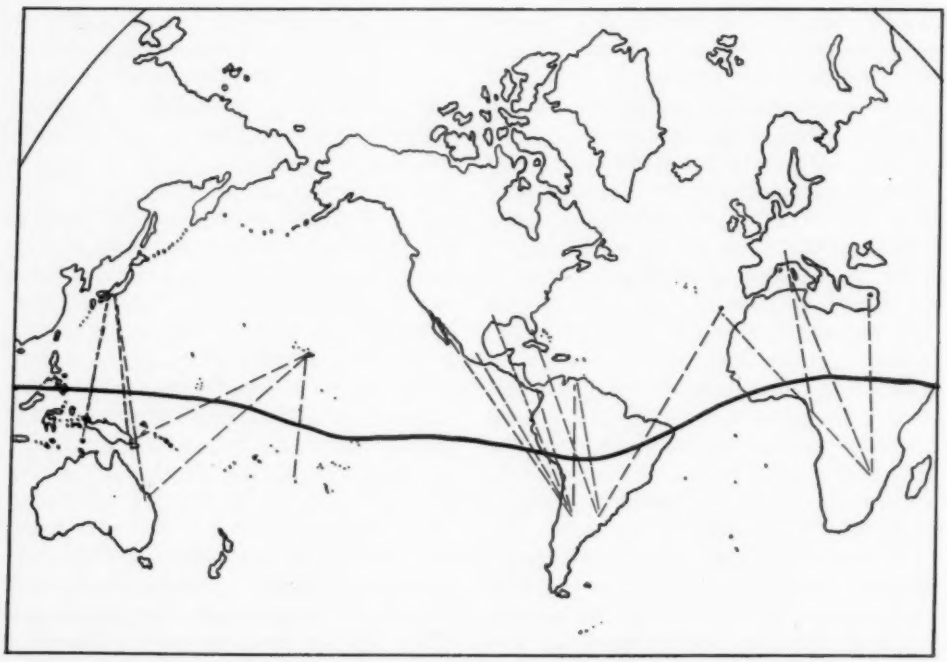

FIG. 2. Some typical paths over which radio contacts have been established by "trans-equatorial scatter," are indicated by the dashed lines. The geomagnetic equator is indicated by the solid line given for reference. (From the monthly bulletin of the ARRL-IGY Propogation Research Project.)

Particles shot out from the sun occasionally hit the earth's atmosphere with sufficient energy not only to excite the gases in the high atmosphere to a glowing state which is visible as the aurora, but also produce significant amounts of ionization. Amateurs have used this phenomenon also to transmit over abnormal distances by listening for auroral reflection of the signals. An interesting feature of this work is the lack of coincidence between the reflecting region and the glowing region of visible aurora; southern locations can frequently employ the technique when northern stations cannot. The reflected signals are characterized by a "fluttery" quality which is due to relative motion in the air that is ionized. A frequency shift in the signals due to a "Doppler" effect is also noticable and has been measured by some amateurs. The Cornell Ionospheric Project utilized data obtained by an extensive network of amateur stations to establish (9) the pattern of radio reception that is possible by this means.

Meteors provide another point of contact between radio amateurs and meteorologists. Small stones enter the atmosphere from space and burn up by friction. As the material of the particle melts it is eroded away, leaving a bright trail (the shooting star) which is ionized. Meteors occur both at random and in well organized "showers." The intensity of meteor trails, the rate of dissipation of the trails, and the displacement they experience while they are still detectable yield important data on the composition of the atmosphere and on the winds from 25 to 100 miles above the earth. Both meteor showers and sporadic meteors are used by hams to reflect radio waves well beyond line-of-sight, the distance over which contacts can be established being dependent, among other things, on the height of the trail. The distribution of the height of appearance and disappearance of meteor trails can be used as evidence of a change in density gradient at high levels. These distributions have so far been confined mostly to visual observations of meteors and therefore are restricted to nighttime conditions. Radio observations of meteors during daylight hours can help in the determination of diurnal changes in density gradient at high levels. So far no project has been organized to study amateurs' records from this point of view.

Scatter techniques of radio propagation have recently been developed to increase the usefulness of the very high and ultra high frequencies. There are two distinct methods of scatter propagation: In one case, radio waves are scattered by the ragged edge of ionized layers; the second method uses inhomogenities in the troposphere to scatter radio waves in much the same way as light from a search light beam is scattered by small particles in the atmosphere so that the beam is visible even when the light source is not. Both ionospheric and tropospheric scatter require the use of considerable power and are still somewhat beyond the reach of amateurs because of a legal limitation on the power an amateur may use in his transmitter. However, more sensitive receivers are being constructed by amateurs with the intention of using these techniques.

One particular type of "scattering" has been almost exclusively the amateurs' province. It has been found possible to transmit signals from the northern to southern hemisphere at frequencies and times that were quite unexpected. The effect occurs in late afternoon or early evening during the equinox months and is confined to a belt that circles the globe at the geomagnetic equator. A co-ordinated effort to study this phenomenon has been organized by the American Radio Relay League in conjunction with the I.G.Y. (10). The world-wide scope of amateur participation in this project and the typical paths over which contacts have been made by this means are illustrated in figure 2. The only professional ionosphere stations currently studying this ionization belt are located in South America. A suggested cause of these signal paths is a "bulging" in the F_2 layer of the ionosphere of just the right shape to allow radio waves to be reflected twice from the layer as illustrated in figure 3 (10).

Although the early work of Hull has been expanded many times over since the shorter

wave lengths have come into general use, there are still occasional amateur activities that are of interest to synoptic meteorologists. For example, the recent record-breaking contact at 2 meters wave length between California and Hawaii was possible because of the inversion under the Pacific High and gives evidence of the remarkable uniformity and strength of this synoptic feature (11).

Conclusions

The greatest opportunities for non-specialists lie in those fields where the raw data are most readily accessible, but where the tremendous volume of observations needed restricts the activity of the professionals. Even in this case the more technically advanced the observer becomes the greater is his potential contribution. The willingness to invest some money and much time, and the capability of constructing good instruments are typical of amateur astronomers and also of amateur radio operators. Much meteorologically useful information can be obtained from this source.

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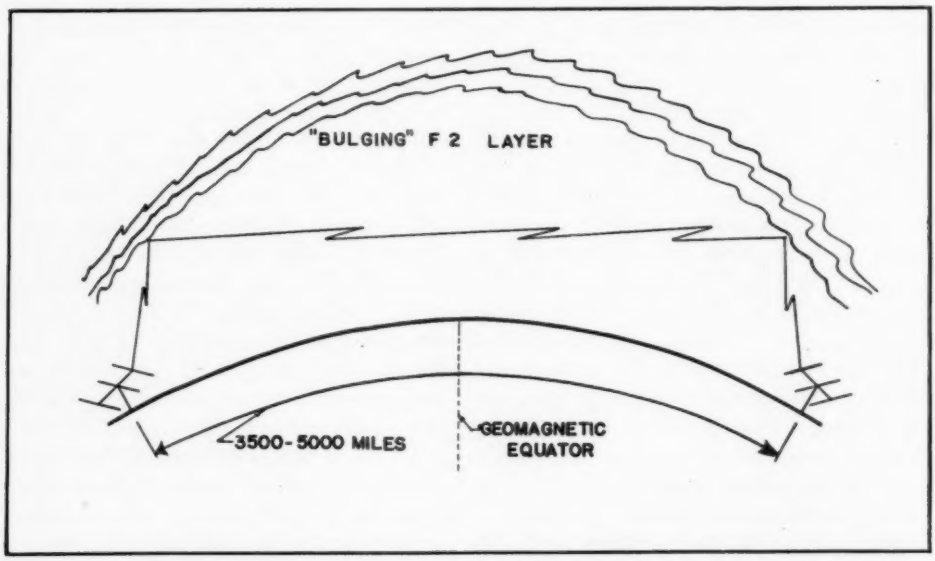


Fig. 3. Illustrating how a "bulge" in the reflecting layer may cause radio signals to be reflected twice from the same layer to permit extra long distance communications. (From the monthly bulletin of the ARRL-IGY Propogation Research Project.)

Don Kent, Boston's popular TV-weatherman flanked by teletype, radio, and facsimilie communications equipment. His left hand is on a special receiver presented to him by the New England Weather Net.

The New England Weather Net

PHIL FOSTER, *Secretary, N. E. Weather Net*

ONE of the usual topics that comes up in conversation in amateur radio is, of course, the weather. Most "hams," however, don't "do anything about it," but a group of New England radio operators in December 1955 decided they would "do something about it."

Each morning at 0630 this group of early-risers reported their weather conditions to a central station (known as a net control station). The reports included: present temperature, barometric reading and tendency, wind direction and speed, and the present sky cover. Precipitation and high and low temperature readings were available from those with suitable facilities. From a small beginning of about six or eight stations, this list has now grown to just under fifty and covers an area from Philadelphia to the tip of Maine and westward to central New York and southern Canada.

The amateur weather reporters have varying degrees of equipment for observing the weather; some even relying on "smoke from the house next door" to gauge wind direction and speed, while others have extensive instrumented recording equipment to provide reports. These records are kept by at least three of the reporting stations as a permanent record of weather conditions from that location.

Just recently, the amateur group (known as The New England Weather Net) presented to Don Kent, the weather reporter from commercial radio station WBZ in Boston, a radio receiver turned to the Weather Net frequency (3.9 megacycles). Now stations report in, beginning about 0550, and by 0625 each day about 30 reports are available which are heard by Don Kent and used on his 0655 radio and TV weather broadcasts. A number of times he has been able to pin-point a low pressure area just off the coast from the reports in that vicinity. They fill the gaps between the official stations and thus expand the coverage of the New England weather reporting service.

Radio amateurs can receive no remuneration for any of their services on the air. So just for the interest in the weather and to hear what it is like in surrounding areas, they

arise, often before dawn, take their readings, and report to the net. The attendance record for many of these amateurs is outstanding, considering that they do it "just for the love of it." Their business and occupations are varied: four doctors, three telephone men, several engineers, automobile salesmen, boat builders, high school students, housewives, etc.

Many amusing and interesting reports have come in over the years. Other amateurs call in for information on road conditions during the winter, flying weather during the summer, and boating weather at all seasons.

At present the control stations are:

Monday	W1YCR, Dr. S. L. Burgess, Waban, Mass.
Tuesday	W1ITX, Charles Jones, Putnam, Conn.
Wednesday	W1MSF, B. R. Mikutajcis, Lexington, Mass.
Thursday	W1BNW, C. Crosby, Osterville, Mass.
Friday	K1BEN, P. Foster, Falls Village, Conn.
Saturday	W1OJM, Frank Shaw, Foxboro, Mass.

These stations call the various reporters in order and permanent records are kept by Chester Crosby, Osterville, Mass.; Henry Appleblad, New London, Conn.; and Phil Foster, Falls Village, Conn.

Stations currently checking into New England Weather Net as of 4/15/59:

Dr. S. L. Burgess of Waban, Mass., reports into the New England Weather Net from his home-built radio station.

Sidney L. M. Taylor reports the weather from Norwood, near Philadelphia, each day. His interest in weather goes back many years as does his activity in amateur radio.

Usual Time	Call	Handle	QTH
0545	K1IIW	Doc	Orange, Mass.
	W1BNW	Chet	Osterville, Mass
	W1NLV	Al	Warren, Maine
0550	K1BEN	Phil	Falls Village, Conn.
	W1IBE	Bill	Rockport, Mass.
0600	W3WL	Sid	Norwood, Penna.
	W2LOP	Hank	Springfield, N. J.
	W2LIY	Charlie	Brooklyn, N. Y.
0605	W1NEK	Henry	New London, Conn.
	W1OQT	Steve	Marthas Vineyard, Mass.
	K1GRP	Ed	Dennisport, Mass.
	K1GRP	Glenn	W. Yarmouth, Mass. (Kn1HBY)

(*Continued on page 117*)

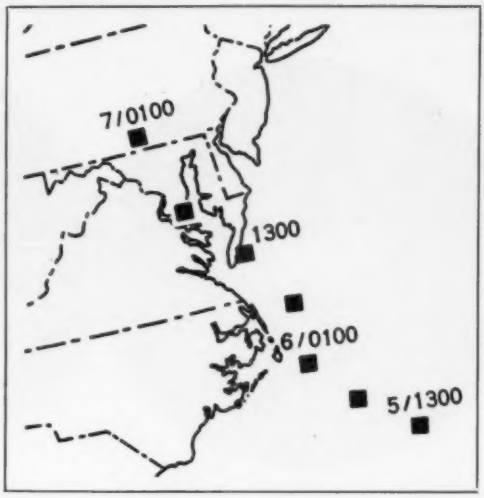


FIG. 1. Track of the low center of the severe East Coast storm of 5–6 October 1957.

Coastal Storm on Cape Hatteras Radar, 5–6 October 1957

ALEXANDER SADOWSKI, *U. S. Weather Bureau*

(Text begins overleaf)

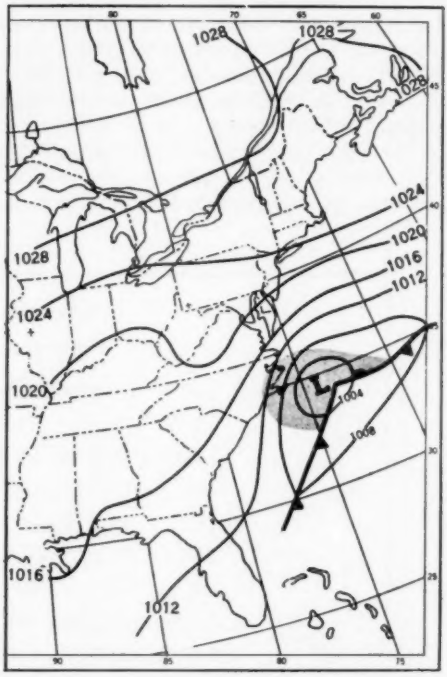


FIG. 2. Simplified Surface Chart, 1900 EST, 5 October 1957.

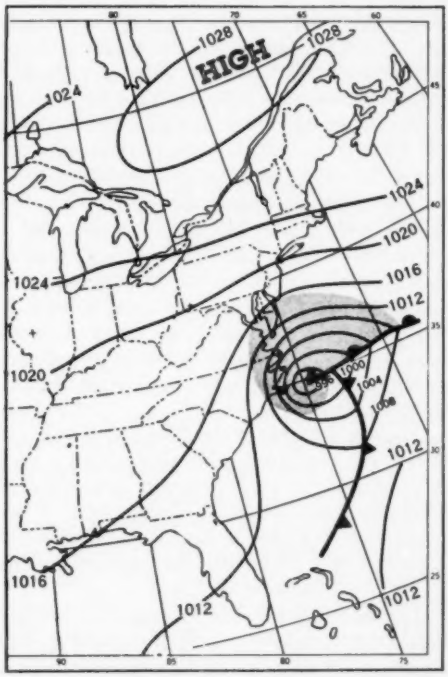


FIG. 3. Simplified Surface Chart, 0100 EST, 6 October 1957.

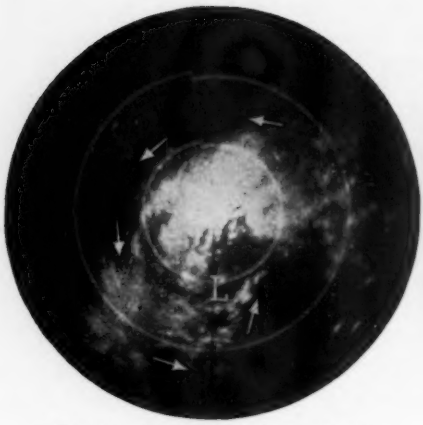


FIG. 4. About 2030E the eye is 65 n. miles SSE.

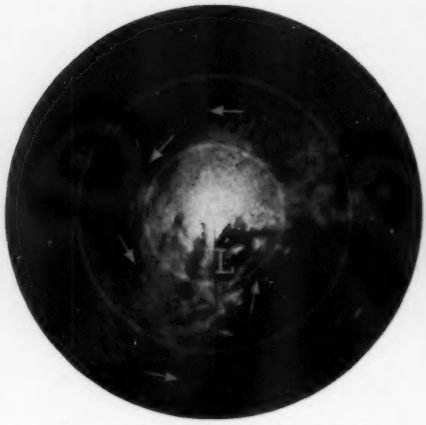


FIG. 5. About 2130E the eyes is about 45 n. miles SSE.

FIG. 6. About 2230E n. miles S

The above photos of the PPI Scope at Cape Hatteras cles are 50 nautical miles apart. Arrows i

ON Saturday night, 5 October 1957, a low pressure area, which had been weak and indefinite for over a 24-hour period, suddenly deepened into a severe storm over the Atlantic Ocean some 80 nautical miles south of Cape Hatteras, North Carolina. Heavy rains and gale force winds of the severe coastal storm type prevailed over the Middle Atlantic States on Sunday with high tides causing damages in the hundreds of thousands of dollars.

The radar then at Cape Hatteras was a SPIM with a wavelength of 10 cms, and a peak power output of 1000 kws. Two pulse widths were available, one microsecond and five microseconds. The photographs were of the long-pulse presentation. The antenna was a 8-foot parabola giving a two-degree beam width. The maximum range is 250 naut. miles.

Striking features of the storm were its rapid deepening combined with an unusual course that carried it northwestward over land as shown in figure 1. Maps of 1900 EST, 5 October and 0100, 6 October, are reproduced in figures 2 and 3 to show the rapid deepening of eight millibars in six hours.

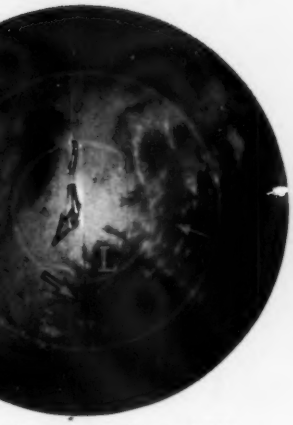
On Saturday evening an extensive precipitation shield moved over Cape Hatteras and appeared on radar oriented northeast to southwest with the individual echo movement being from the northeast. The first evidence of circulation of the echoes was the appearance of an elongated echo measuring about 15 by 40 naut. miles, on the eastern side of the main rain shield, with the echo's circulation from the south to give an apparent center about 65 naut. miles, south-southeast of Cape Hatteras at 2030 EST as shown in the radar scope photo of figure 4.

The term "eye" is used in connection with this extratropical cyclone to emphasize its similarity on a radar PPI scope to that of a hurricane.

OBSERVATIONS AT C

LATE 5 OCTOBER — E

1830E	E8◍80⊕5TR—↓↙26+3	
1855E	M◍ ⊕ 5TR—	058/6
1954E	M◍ ⊕ 5TR—	051/6
2055	E8◍25⊕5R —	034/6
2155	E5◍25⊕5R —	024/6
2255	E5◍25⊕5R —	003/6
2355	E5⊕ 5R —	980/6
0055E	E9◍25⊕5R —	966/6
0157E	E14⊕7	953/6
0250E	7◍E10⊕5R —	966/6
0554E	E10⊕8	014/6



About 2230E the eye is 30 n. miles SE.

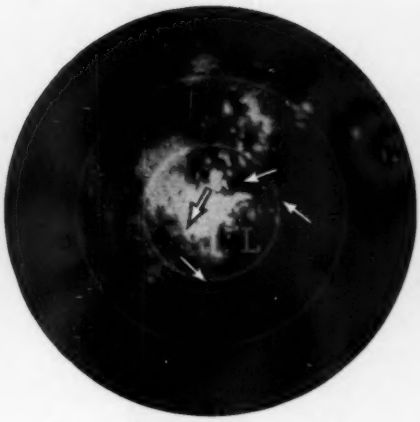


FIG. 7. At 0100E the eye is 40 n. miles E by S.

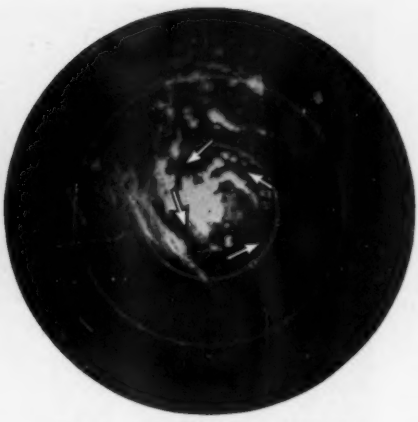


FIG. 8. Shortly before 0130E the eye is 15 n. miles East.

Cape Hatteras on 5–6 October 1957. Concentric range cir-
t. Arrows indicate the circulation of the echoes.

By 2130 EST, a definite circulation of the storm's echoes, showing an oval "eye" of about 15 naut. miles diameter, south-southeast of Cape Hatteras, was readily identifiable on radar as shown in radar scope photograph of figure 5. The associated precipitation shield bears some resemblance to that of a hurricane as seen on a radar scope except for the lack of clearly defined spiral bands. The rate of advance of the storm during the hour preceding this photograph was approximately 20 knots.

An hour later, the "eye" was 30 naut. miles southeast of station as shown in figure 6.

Shortly after midnight, the "eye" was located 40 naut. miles from Cape Hatteras on azimuth of 100° (fig. 7). At 0130 EST, the "eye" was 15 naut. miles to the east (fig. 8). The station barogram showed the lowest station pressure was 29.37 inches (994.7 mb) at 0130 EST.

In conclusion, this series of photographs of the PPI scope shows the capability of this type of powerful, 10-cm, radar to present the circulation of an intense coastal low such as occurred on 5–6 October 1957. The radar presentation of the low was unique in that it resembled in some degree a hurricane echo pattern with the characteristic features of an "eye" of 15 miles diameter outlined by echoes circulating cyclonically and a well-defined rain shield approaching the station from the ocean to the southeast. That radar can be used to track the movement of such well-defined storms by observing the movement of the "eye" and the precipitation pattern to determine the storm's direction and speed was demonstrated. Further development of this capability, especially over coastal waters where surface reports are sparse or lacking and where cyclogenesis is common, should materially help the forecaster.

IONS AT CAPE HATTERAS
TOBER — EARLY 6 OCTOBER

↓↙26+34/T OVHD TB30
058/66/66↓↙28+37
051/66/66↓27+37 T OVHD
034/65/65↓29+40 T E35 G45
024/65/65↓29+42 736 172X
003/66/66↓↘21+42 PRESFR
980/66/66↓↘28+39 PRESFR
966/66/65↓29+44
953/68/68↓11
966/66/64→↘27+36/RB40
014/62/59→24+34/PRSRR

FIG. 1. Camera aimed south south-west at 1815 MST. All photos taken from location mark (4) in figure 4.

FIG. 2. Camera aimed west at 1820 MST.

FIG. 3. Camera aimed northwest at 1817 MST.

A Desert Dust Storm Strikes El Paso, Texas

HARRY L. ELSER, *United States Weather Bureau, El Paso*

DUST storms associated with drought conditions periodically receive a good deal of public and scientific attention. Documentation of these "dust bowl" type storms has been fairly complete down through the years including several excellent photographs. "Drought and Dust in the Midwest," published in *Weatherwise* June 1953, is one example of the literature that is available on the subject.

The accompany photographs show a different type of dust storm that seems to have attracted much less attention though such storms play a familiar annual role in the weather scene over the desert plateau section of the Southwestern United States each spring. Caused by dry, high-level (cloud bases around 10,000 feet above the ground) thunderstorms, they occur most often during late May or June when the westerly circulation of winter is giving way to easterly circulation for the summer. The young easterlies of early summer are unable to penetrate the desert plateau area with sufficient moisture from the Gulf of Mexico to set off the wet thunderstorms that mark the summer "rainy season." However, long sunny days permit convective heating to altitudes of 20,000 feet so that, even with little moisture available, a few high-level thunderstorms develop over the desert and mountains of the plateau area almost daily. These high-level thunderstorms seldom produce more than a trace of precipitation at the surface because of the extremely high rate of evaporation in the hot, dry air beneath the cloud (1). Otherwise the storms seem to follow the standard life cycle pattern as described by Byers (2). Explanation of the desert dust storm can begin with the mature stage when the downdraft reaches the ground to establish a micro-cold front. Since there is little or no rain to dampen the desert floor the downdraft winds stir up huge clouds of dust that, on occasion, dramatically outlines the micro-cold frontal surface. Once the dust cloud is formed it may drift across the desert for several hours, in many cases, outliving the parent thunderstorm cloud.

The storm pictured here occurred on 28 June 1957 during a heat wave that matched the El Paso station record of ten successive days with temperatures of 100° or higher. On the day of the storm a new extreme maximum temperature of 107° was recorded. At the time the pictures were taken the leading edge of the dust wall occupied an approximate composite position given by the line A-B in Figure 4 which is a map of El Paso and the surrounding terrain. Wind records from the American Smelting and Refining Company

indicated that the strong winds accompanying the leading edge of the dust wall reached their instruments at 1814 MST. Eight miles east and fifteen minutes later at 1829 the dust wall reached the International Airport indicating an eastward speed of just under 30 mph. The storm lasted nearly four hours during which the visibility was restricted to near zero for the first hour, westerly winds averaged 40 mph with gusts to 70 mph and a two-inch layer of dirt was deposited in local swimming pools. The wind speeds recorded at International Airport were probably stronger than should be attributed to the downdraft circulation alone since westerly winds tend to funnel through a pass formed by the Rio Grande cutting through the Franklin and Juarez Mountain chain just west of the airport.

While the type of dust storm pictured here can hardly be compared to the "black blizzards" of the thirties, the suddenness with which they strike and their severity while they last make them a weather phenomenon to be reckoned with by inhabitants of the Southwestern Desert Plateau.

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2. Byers, H. R., "Thunderstorms," in: *Compendium of Meteorology*. American Meteorological Society, 1951, p. 681.

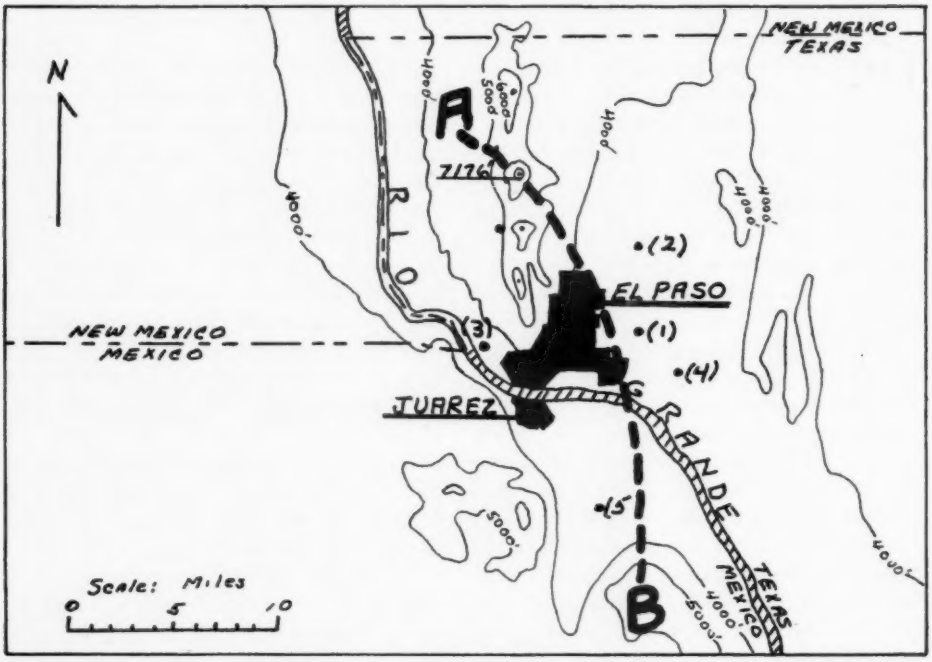


FIG. 4. Map showing El Paso, Texas and the surrounding terrain. The heavy line A-B shows the approximate composite position occupied by the dust wall at the time the pictures were taken. General movement of the dust storm was from lower left to upper right. Numbered locations are as follows:

(1) United States Weather Bureau, International Airport
(2) Biggs Air Force Base
(3) American Smelting and Refining Company
(4) Position pictures were taken from
(5) Juarez Airport, Chihuahua, Mexico

The New England Weather Net (*Continued from page 110*)

Usual Time	Call	Handle	QTH
0610	W1RJL	George	Cape Cottage, Maine
	K1COY	Bill	Nashua, N. H.
0615	K1GCS	Jack	Guilford, Conn.
	WA2DVS	George	Schenectary, N. Y.
	W1AWW	Frank	Springfield, Mass.
	W1MOI	Betty	Newport, Mass.
	W1OJM	Frank	Foxboro, Mass.
	W1ITX	Charlie	Putnam, Conn.
0620	W1DQ	Hal	Warren, R. I.
	W1DPO	Paul	Chatham, Mass.
	W1MSF	Ben	Lexington, Mass.
	W1SDG	Burns	Brattleboro, Vt.
	K1CJO	Ed	Eliot, Maine
	W1LOS	George	Sharon, Mass.
	VE2AZI	Frank	Magog, Que.
0625	Run-down of stations checked in		
0630	W1YCR	Doc	Waban, Mass.
	W1KMG	Bob	Hancock, Maine
	VE2OO	Sparks	St. Dorothee, Que.
	W1SEO	Doc	Hinesburg, Vt.
	W1UHI	Ernie	Vergennes, Vt.
	W1BMW	Al	E. Harwich, Mass.
0640	K1BKH	Hote	E. Calais, Vt.
	W1UV	Hugh	Conway, Mass.
	K2LMS	Alice	Lake Luzerne, N. Y.
	W1VSZ	Lou	Centredale, R. I.
	W2RTG	Woody	Lairdsville, N. Y.
	K2ZJF	Walt	Wyckoff, N. J.
0645	K1EEN	Jack	Hanover, N. H.
	W1KYT	Grace	Middleton, Mass.
	W1HKN	Marsh	Slatersville, R. I.
	W1THD	Amos	E. Longmeadow, Mass.
	W1EOP	Walt	Calais, Maine
	W3KAN/m	Mac	Silver Spring, Md.
	K1BFJ	Jack	Deep River, Conn.
	W2GTB	Warren	Schenectady, N. Y.
	K2ICF	Pete	Chappaqua, N. Y.
	W2QAY	Rex	Camden, N. Y.
	W2SHL	Joe	Browns Mills, N. J.
	K1CKH	Happy	Paistow, N. H.
	W1NR	Chet	Fairfield, Conn.
	W1WXI	Hal	Dixfield, Maine

on 19 May, he expressed his doubt once more: "What they say of the 19th of April, '75 . . . could only have been said within a week past this early year."

As always in his study, he carried his researches back to what he could learn about the attitude of the aborigines toward weather and their adventures in it. "The charm of the Indian to me," he said, "is that he stands free and unconstrained in Nature, is her inhabitant and not her guest, and wears her easily and gracefully." While he was still an undergraduate at Harvard he had written of the savage:

> The earth is his hunting-ground . . . the sun is his time-piece. . . . He never listens to the thunder but he is reminded of the Great Spirit. . . . To him the lightning is less terrible than it is sublime; the rainbow less beautiful than it is wonderful; the sun less warm than it is glorious.

In the extensive program of reading which is revealed in the eleven unpublished volumes of "Extracts, from Works relating to the Indians," now in the collections of the Pierpont Morgan Library, he learned to temper the romantic enthusiasm of his early statement, however. Sometimes the thunder reminded the Indian of the Great Spirit—but a Great Spirit with a tumult in his stomach as he tried to vomit up the great adder which would later leave his jagged mark on a tree. Sometimes the thunder was the beating of an eagle's wings; and the lightning, the flashing of his eye. From Father Charlevoix he learned that the Canadian Indians thought an eclipse a great combat in the sky and shot their arrows at it; that the Hurons, distressed by the sickness of the waning moon, made a great noise to assist it back to the full, and beat their dogs. The meteorology and astronomy of the Indians were mostly poetry, but he had also noted in his undergraduate essay that the life of the savage 'is practical poetry, a perfect epic." He was especially interested in the names by which the Indians recognized the various "moons," since those names indicated the quality of their natural observation. Into his Notebooks he copied endless lists of those names—mostly from the tribes of Canada and the Middle West, since he found few or none in the chronicles of New England—noting that the great variety derived from the difference of natural facts in different places. Thus February was to certain Canadian Indians *the moon of hard or crusted snow* but to the Dacotas it was *the moon in which raccoons run.* March was to the Montagnais *the moon of the skunk;* to other tribes visited by the Baron de la Hontan, *the moon of worms, because they come out of trees then;* to the Dacotas, *the moon of sore eyes.*

Of greater practical value was the information he gleaned concerning the planting and harvest of Indian corn. Here again he found poetry, but it was truly practical poetry. From Alexander Henry's *Travels and Adventures in Canada and the Indian Territories,* the Rev. John Heckewelder's "An Account of the History, Manners and Customs of the Indian Nations, who once inhabited Pennsylvania," and C. E. Potter's *The History of Manchester . . . New Hampshire* he copied the identical bit of lore, that the Indians planted their corn "when the leaf of the white oak is as large as a mouse's ear." He recorded also all the tales of remarkable success among the Indian jugglers in manipulation of the weather, but something in his tone suggests that he took little stock in such Indian "signs" as that to roll loose pebbles down a hill in making one's path through the forest will infallibly produce rain—a detail gleaned from John Bartram's *Observations.*[4]

It is obvious, of course, that Thoreau did not restrict his study of weather to New England. He was interested in weather everywhere, and in all aspects of it. Into one of his voluminous "Fact-Books," entitled "Extracts, Mostly from Natural History," now owned by Harvard University, he copied passages from Sir Francis Head's *The Emigrant* on "Flies altering the Climate of N. Am.," from Sir John Richardson's *Arctic Searching Expedition* on "Progress of the Seasons at Fort Franklin, on Great Bear Lake," from William Gilpin's *Observations on the River Wye . . . in 1770* on "Effect of Rain," from S. H. Hammond's *Hunting Adventures in the Northern Wilds* on "Signs of Rain in the Wilderness," from Cook's *Voyages* on the "Climate of Kamtschatka."

Like every weather prophet, Thoreau was

[4] I have quoted details from Thoreau's Indian Notebooks (preserved as MA 596–MA 606) by permission of the Trustees of the Pierpont Morgan Library.

a student of "signs"; his writings, published and unpublished, abound in them—and, again, he did not restrict himself to signs which were current in New England. Into another Fact-Book, now in the Berg Collection of the New York Public Library, he copied a series of weather signs. From the "De Signis Pluviarum" of Theophrastus, for example, he noted that a tempest may be expected when the fire kindles with difficulty; that a swelling foot foretells a change to a south wind; that a hard winter may be expected when mice squeak and leap, when cows eat more than usual and lie down on the right side, when the ass shakes his ears, when dogs dig the earth with their feet.[5] From Brand's *Popular Antiquities* he noted that "When the cat washes her face over her ears, we shall have a great storm of rain." He quoted the old verse,

> If the grass grows in Janiveer,
> It grows the worse for't all the year,

and added in a parenthesis, "When it was so warm in January, W^m^ Wheeler said—'We shall want this weather next summer.'" From Henry Y. Hind's *Narrative of the Canadian Red River Exploring Expedition* he noted that Hind "Observed . . . the grasshoppers descending from a great height perpendicularly, like hail—a sign of approaching rain." He noted also that "Virgil mentions among signs of rain 'The cow looking up to the sky.'"

Whenever he traveled beyond Concord, he was prepared to discuss weather with the natives. On Cape Cod, for example, he talked with an old man who "thought . . . he could tell all about the weather from the sounds which the sea made" and called his attention to "a peculiar roar of the sea before the wind changes." In writing about the incident, Thoreau added:

> Old Josselyn, who came to New England in 1638, has it among his weather-signs, that "the resounding of the sea from the shore, and murmuring of the winds in the woods, without apparent wind, sheweth wind to follow.".

Later, hearing the roar of the surf, he was told by the inhabitants that "it was a sign that the wind would work round east, and we should have rainy weather"; but he did not finally credit the ability of sailors to predict the weather from such signs. Traveling in New Hampshire during his famous "Week," he gathered from Jeremy Belknap's history the information that

> in the neighborhood of fresh rivers and ponds, a whitish fog in the morning lying over the water is a sure indication of fair weather for that day; and when no fog is seen, rain is expected before night.

In the Maine woods he learned that the sight and sound of a loon portended wind, that the "whistle" of a snake was a sign of rain, as was the morning song of the robin.

He had his informants in Concord, too, where the weather was naturally of special importance to him. Goodwin told him, for example, that "when you hear a woodpecker's *rat-tat-tat* . . . on a dead tree it is a sign of rain." Nat Rice, fishing on Flint's Pond, gave him the practical bit of related information that the best time for success in the sport was "When the wind first comes south after a cold spell, on a bright morning." Minott told him, on the authority of "some old worthy," that "the bark of the striped squirrel is the, or a, first sure sign of decided spring weather." Mr. Prichard reminded him one January that there would be no thaw while the moon was so inclined that one could hang a powder-horn on it. These men were practically aboriginal, living close to nature and dependent on it. Hosmer's word was more doubtful, as Thoreau noted in his Journal after hearing owls at sundown on 20 November 1851 while he was surveying in the swamp:

> Hosmer said: "If you ever minded it, it is about the surest sign of rain . . . there is." . . . "But night before last," said I . . . "they hooted louder than ever, and we have had no rain yet." At any rate, it rained hard the 21st.

Hosmer's word was better, however, than that of the haymakers in Hubbard's meadow, who told him,

> the cock says we are going to have a long spell of dry weather or else very wet. "Well, there's some difference between them," I answer; "how do you know it?" "I just heard a cock crow at noon, and that's a sure sign it will either be very dry or very wet."

[5] Channing, commenting on Thoreau's interest in signs, said, "[He] . . . found from [Theophrastus] that neither the weather nor its signs had altered since his day. Pliny's . . . was his last reading in this direction, a work so valuable to him . . . [with that of others] that he meant probably to translate and write on the subject as viewed by the ancients. As illustrations, he carefully noted many facts from modern travellers." (*Thoreau: The Poet-Naturalist* . . . New Edition . . . Edited by F. B. Sanborn [Boston 1902], p. 61.)

Thoreau's own observation of the weather and its signs was often less poetically expressed, but sounder and more trustworthy. He came, indeed, to be regarded as a sort of local oracle on the weather. He wrote in his Journal, in 1858:

When I came down-stairs this morning, it raining hard and steadily, I found an Irishman sitting . . . in the kitchen, waiting . . . to inquire what I thought the weather would be to-day! I sometimes ask my aunt, and she consults the almanac. So we shirk the responsibility.

He did not often, or seriously, shirk the responsibility, however. "Wind was easterly yesterday," he wrote, "hence snow and rain today."

I think . . . this is the seventh rainstorm . . . [in the past month] which resulted from the wind becoming easterly on the previous day, after having been in each instance but one northwest the day before, and that once the previous day was quite calm.

Several times he noticed that crows came near human habitations "in very cold weather and deep snows." One finds Thoreau often poetic on the subject of weather, as when, observing that the color of ice on a winter evening and its booming foretell a sinking temperature, he wrote, "The ice displays its green flag and fires its evening gun as a warning to all walkers to return home." He phrased his practical suggestions with a touch of poetry:

I believe the 14th [of June] was the first day I began to wear my single thin sack and at night sleep with both windows open; say when the swamp-pink opens.

This year the time when the locust was first heard was the time to put on summer clothes.

Since summer is a fleeting season in New England, merely a pause between winters, Thoreau gives it only a passing attention, just enough to suggest a few rules for the prediction of rain or drought. He was more concerned with the signs to predict the severity of the winter, the signs of snow during winter—the sudden appearance of a flock of snowbirds, for example—and the signs by which one could in winter predict the quality of spring. In late fall he found certain signs in his own mood. Although occasionally he could remark that "This clear, cold, Novemberish light is inspiriting. . . . Your thoughts sparkle like the water surface and the downy twigs," he was more often moved to say, "In November, a man will eat his heart, if in any month." His mood dropped also in March:

He must have a great deal of life to him to draw upon, who can pick up a subsistence in November and March. Man comes out of his winter quarters this month [30 March 1855] as lean as a woodchuck. . . . Except for science, do not travel in such a climate as this in November and March.

The true son of New England is to be judged by his devotion to winter, a devotion which must be carefully distinguished from a lot of sardonic and even angry talk about it. Thoreau meets the test squarely. "So sweet and wholesome is the winter," he wrote, "so simple and moderate, so satisfactory and perfect. . . . It is solid beauty." "Ah, who can tell the serenity and clarity of a New England winter sunset?" It was to him "the russet afterglow of the year." "I think the summer rarely equals it," he declared.

There are real damask-colored isles or continents north of the sun's place, and further off northeast they pass into bluish purple. Hayden's house, over which I see them, seems the abode of the blessed.

Not only was winter a time of beauty, when the shadow he cast was "a most celestial blue"; it was a season when his familiar countryside was transformed into the primitive waste which the Indians had seen. "It would be dangerous for a stranger to travel across the country now," he said, himself a little uncertain of where he was. Concord was a new land then, a land which offered exciting opportunities for exploration, and he again knew that home offered something of everything which foreign and exotic places could show. "I love to wade and flounder through the swamp now, these bitter cold days when the snow lies deep," he wrote,

. . . and I need travel but little way from the town to get a Nova Zembla solitude,—to wade through the swamps all snowed up, untracked by man. . . . This is instead of a Polar Sea expedition and going after Franklin.

Winter returned him also to thinking about the essential meaning of religion and the true relation of scripture to his own life:

We know of no scripture which records the pure benignity of the gods on a New England winter night. Their praises have never been sung, only their wrath deprecated. The best scripture, after all, records but a meagre faith. Its saints live reserved and austere. Let a brave, devout man spend the year in the woods of Maine or Labrador, and see if the Hebrew Scriptures speak adequately to his condition and experience, from the setting in of winter to the breaking up of the ice.

He learned that the Indians had placed as much importance on the fact of winter as he

did—more, indeed, although they might not have praised its beauty so highly. From Lawson's *Carolina* he copied the detail that the Indians determined their ages by the number of their winters; that they also calculated the years in winters he discovered in the Jesuit *Relation* for 1634, in Robert Beverley's *Virginia*—and in David Crantz's *History of Greenland*. From Indian lore he drew such signs of an approaching hard winter as an abundance of acorns in the fall and an unusual thickening of corn-husks in the summer. Noting that in New England winter the northwest wind prevails, he was not surprised that "the Indians placed their heaven in the southwest on account of the warmth of the southwest wind." After the annual northeaster of October 1857, contemplating the providential arrangements of nature, he wrote:

> The Indians, it is said, did not look for winter till the springs were full. Long-continued rain and wind come to settle the accounts of the year. . . . The ducks and other fowl, reminded of the lateness thus, go by.

When he was preparing his account of his excursion to Canada—a summer excursion—he accomplished a great deal of research in Canadian winter, and was sufficiently fascinated to record much of it in his Canadian Notebook.[6] He studied the difference between the length of winter in Montreal and Quebec, quoting from *The Transactions of the Literary and Historical Society of Quebec* the information, "Winter at Quebec from Nov 25 to April 25—fortnight or 3 weeks dif. bet Quebec & Montreal"—having previously quoted from Joseph Bouchette's *Topographical Description of Lower Canada* that the differential was five or six weeks. He noted further, "5 months sleighing in Lower Canada 2 months in Upper. Snow 30 inches deep on an average," and he added a detail from George Warburton's *Conquest of Canada*, "Milk 'is sold by the pound.' " He described the ice formations on the St. Lawrence, caused by spray from waterfalls, remarking that the spectacular formations of 1829 had followed a season of unusual humidity. He learned from Kalm that the ice in the St. Lawrence broke at Montreal on 3 April, at Quebec on 20 April. From Benjamin Silliman's *Remarks . . . on a . . . Tour, between Hartford & Quebec* he noted that the winter cold at Cape Diamond reaches "almost or quite, to the freezing point of quicksilver"; from Head's *The Emigrant*, that the head-on effects of winter cold were like strong acid striking the face, so that the cheeks of twenty soldiers were frost-bitten in a windy march of one hundred yards: "The frozen fingers or toes break off like brittle sticks." His somewhat admiring conclusion was "Think of travelling in a country where the very bears . . . for 6 months . . . dare not show themselves to the air."

Especially he studied the accounts of the severe winters which mark the epochs in New England's history. He jotted down in his Fact-Book, for future reference and verification, William Wood's statement in *New England's Prospect:*

> "It is observed by the Indians that every 10th year there is little or no winter, which hath been . . . observed by the English"—viz 1620—& 1630 both times of Plymouth—& Mass. settlement.

Such information might prove handy in long-range prediction which would be valuable to report to men for the guidance of their lives. In the Journal of the Rev. William Adams, which he read in the *Collections of the Massachusetts Historical Society*, he found such details as that in 1670 the first snow fell in Cambridge on 1 December, "it being hardly over shoes," but that in 1671 the snow was "almost knee deep" on 24 November. When "The Long, Snowy Winter"[7] of 1855–1856 arrived, he sought out Cotton Mather's account of the severe snowfall of 1717 and copied its details, adding the terse comment: "He little thought that his simple testimony to such facts . . . would be worth all the philosophy that he might dream of." He read accounts of the great snows of 1760 and 1780. Uncle Charles Dunbar had been born in February of the latter year; when he died, in March 1856, "the winter of another great snow," Thoreau commented in his Journal on "a life bounded by great snows."

During the months between Christmas Day 1855 and 3 April 1856—when "Young Desmond of the Factory" drove his sleigh into

[6] The Canadian Notebook is preserved in the Pierpont Morgan Library under the title "Extracts from Works, relating to Canada" as MA 595. I quote from it by permission of the Trustees of the Pierpont Morgan Library.

[7] So he headed the new volume of the Journal, which he began on 4 January 1856.

Concord a hundred times, at the rate of one trip a day—Thoreau was in a state of high scientific and historical excitement. He took temperatures and measured the snowfall constantly. It was reported to him that the ice on Nagog Pond was thirty-seven inches thick in places, and he learned for himself that between 13 January and 13 March the snow was constantly not less than sixteen inches deep "on a level in open land." Eb. Conant said the snow was deeper than since 1803, but Dr. Jarvis said there had been as much in '35, when he drove his sleigh from 23 November to 30 March, "excepting one day." Thoreau asked other old natives for information about past winters, and when he got inadequate data, he exclaimed disgustedly, "Of what use to be old?" He quizzed his mother and Minott on their recollections of the famous Cold Friday in Concord—which, according to Shattuck's *History of . . . Concord,* was actually Tuesday, 1 February 1814, when the temperature dropped to twelve degrees below zero.[8] Mrs. Thoreau remembered that "the dishes which the Hardy girl was washing froze as fast as she washed them, close to the fire"; and Minott remembered "seeing them toss up water in a shoemaker's shop, usually a very warm place, and when it struck the floor it was frozen and rattled like so many shot." On the day after his conversation with Minott, Thoreau recorded in his Journal, possibly with pride, "The coldest day that I remember recording. . . . Ink froze. Had to break the ice in my pail with a hammer. Thermometer at 6.45 A.M., − 18°.[9] With further reference to the Cold Friday, it was matter of satisfaction to record the testimony of the "old folks" that "this is as cold as that was."

In the summer of 1855 he had been concerned to discover the truth of the tradition repeated to him by James Small, the keeper of the lighthouse at North Truro, that the Atlantic off Cape Cod never freezes in the winter—or had not, at least, since 1680. When it did freeze, as far as a mile from shore, in February 1856, he recorded the fact with some excitement as "a phenomenon which, it is said, the oldest have not witnessed before."[10] And when Boston Harbor froze over during the following winter, he made a special trip to see it, saying that it reminded him of "Parry's Winter Harbor, with vessels frozen in."

Thoreau could forget the importance of philosophy when he came upon such exciting adventure or read about a blizzard, like that of 1717, so great that even the oldest Indian could not recall the like of it. He insisted, "I omit the unusual—the hurricanes and earthquakes—and describe the common," but the minutiae of disaster, disaster at least derivative from weather, were as thrilling to him as they commonly are to less Transcendental men. As a matter of fact, he did copy into his Fact-Book William Bradford's descriptions of a hurricane in Plymouth in 1635 —which "caused the sea to swell . . . above 20 foot high, right up & down, and made many of the Indians to climb into trees for their safety"—and an earthquake in 1638, and was in sufficient anxiety to determine the exact date of each that he looked up the additional authorities of Winthrop and Alexander Young.

The scholar was Transcendental only when the mood of exaltation—or depression—was upon him, as when he declared that "the truly weather-wise will know themselves and find the signs of rain in their own moods, the aspect of their own skies." There was time for Transcendentalism only after he had studied the facts among the fancies and knew that his statements rested on truth—historical truth, at any rate, as far as he could discern it. As for predicting the weather, that in itself is a Transcendental occupation, as perhaps Thoreau meant to imply when he quoted Minott on what "Old John Nutting used to say," that " 'When it is cold it is a sign it's going

[8] There is, either in Thoreau's discussion of this event or in Shattuck's reference to it, an obvious confusion of dates. The Cold Friday is elsewhere dated as 19 January 1810.

[9] He forgot, apparently, that during the previous winter, on 6 February 1855, the temperature had fallen considerably lower. He had then written in his Journal: "Sheets froze stiff about the faces. . . . People dreaded to go to bed. The ground cracked in the night as if a powder-mill had blown up. . . . My pail of water was frozen in the morning so that I could not break it. Must leave many buttons unbuttoned, owing to numb fingers. Iron was like fire in the hands. . . . The cold has stopped the clock."

[10] Talking with Small again, on 18 June 1857, he learned that "The sea was not frozen there exactly as I had inferred from the papers last winter. Small never knew it to be frozen smooth there so as to bear, but there was last winter a mere brash of pieces several inches thick reaching out half a mile or more. . . ."

to be warm,' and 'When it's warm it's a sign it's going to be cold.' "

Much has been written in recent years about the achievement of Thoreau in science, and it is doubtless true that, as one critic has said, if he had gone to Yale, where he might have come under the influence of Benjamin Silliman, instead of to Harvard, he might have become one of the significant natural scientists of his day. But there were elements in science, and methods, which, despite their fascination for his inquiring mind, he deplored and resented. Science, pure science, was cold and inhuman. The tyranny of minute observation kept drawing his mind away from its real and exalted responsibility to humanity.

> Science affirms too much. Science assumes to show *why* the lightning strikes . . . but it does not show us the moral *why* any better than our instincts did. It is full of presumption.

Science robbed the imagination, which is the motivating power of man's chief glory, the mind.

> I, standing twenty miles off, see a crimson cloud in the horizon. You tell me it is a mass of vapor which absorbs all other rays and reflects the red, but that is nothing to the purpose, for this red vision excites me, stirs my blood . . . and I have new and indescribable fancies, and you have not touched the secret of that influence. If there is not something of mystical in your explanation. . . . If there is nothing in it which speaks to my imagination, what boots it? What sort of science is that?

"It is the subject of the vision, the truth alone, that concerns me." The final circumstance which made it impossible for Thoreau to follow the gleam of science consistently was that too often it merely stated its facts—as who should know better than he?—without relating them to the lives of men. "The sum of what the writer . . . has to report is simply some human experience, whether he be poet or philosopher or man of science," he said.

> If it is possible to conceive of an event outside to humanity, it is not of the slightest significance. . . . I cannot help suspecting that the life of these learned professors has been almost as inhuman and wooden as a rain-gauge or self-registering magnetic machine.

When he killed a cistudo in order to make a scientific examination of it, he had "a murderer's experience" and prayed for greater innocence:

> Such actions are inconsistent with the poetic perception, however they may serve science, and will affect the quality of my observations. . . . No reasoning whatever reconciles me to this act.

Thoreau could never escape the lure of the scientific, because it was too deeply interesting to him; all his life he continued to take the temperature of Brister's Spring and Musketaquid—and all his life he continued to inveigh against the practice. Consistency was no more a hobgoblin of his mind than it is of New England's weather.

His interest in the weather did not cease until he did—after having caught the cold that began his fatal illness by failing to remember that one must make concessions to bad weather if one would live according to natural law. Meanwhile he gloried in the changing elements, loving them best when they were most savage, remembering then in particular that "Nature has not changed one iota" and feeling again his kinship with the early settlers and the same pride they felt in "weathering it out."

There was a great snow when he was at Walden, and he wrote of it later:

> When the snow lay deepest . . . I lived . . . like that early settler's family in . . . Sutton . . . whose cottage was completely covered by the great snow of 1717 . . . and an Indian found it only by the hole which the chimney's breath made in the drift. . . . But no friendly Indian concerned himself about me; nor needed he. . . . The Great Snow! How cheerful it is to hear of! When the farmers could not get to the woods and swamps with their teams, and were obliged to cut down the shade trees before their houses, and when the crust was harder, cut off the trees in the swamps, *ten* feet from the ground, as it appeared the next spring.

Here was raw nature dwelling in the habitations of men, in such a way that men could not overlook it. Here was good news from old New England which had a message for today. Thoreau found in the tales of great snows and great freshets and memorable winds a favorable omen for Transcendental reflection, not only on the essential goodness of the life of the past but on the greatness of the future of America:

> I trust that these facts are symbolical of the height to which the philosophy and poetry and religion of her inhabitants may one day soar. . . . I believe that climate does thus react on man,—as there is something in the mountain air that feeds the spirit and inspires. . . . I trust that we shall be more imaginative, that our thoughts will be clearer, fresher, and more ethereal, as our sky,—our understanding . . . broader, like our plains,—our intellect generally on a grander scale, like our thunder and lightning . . . and our hearts shall . . . correspond in depth and breadth and grandeur to our inland seas. . . . Else to what end does the world go on, and why was America discovered?

If the highest hopes of Thoreau in these respects have not been fully realized, we may yet look to him for a note of literally chilling prophecy, which may be less chilling than others we hear, from the scientists of possibly less humanity:

> We need not trouble ourselves to speculate how the human race on this globe will be destroyed at last, by fire or otherwise. It would be so easy to cut their threads any time with a little sharper blast from the north.

Hurricane Girls of 1959

It will be Arlene to Zasu this year as hurricanes appear in the Atlantic Ocean and Gulf of Mexico areas. Washington weather officialdom has decided to "honor" the following ladies in 1959: ARLENE, BEULAH, CINDY, DEBRA, EDITH, FLORA, GRACIE, HANNAH, IRENE, JUDITH, KRISTY, LOIS, MARSHA, NELLIE, ORPHA, PENNY, QUELLA, RACHEL, SOPHIE, TANYA, UDELE, VICKY, WILMA, XCEL, YASMIN, ZASU.

National Hurricane Research Center

The Research Operations Base of the National Hurricane Research Project at West Palm Beach has been combined with the present Hurricane Warning Center at Miami. The combined unit will be known as the National Hurricane Center. From this location, further experimental work and data collection on the hurricane problem will be directed and programs of applied research accelerated so that results may be put into operational use at the earliest possible date.

The combined Center at Miami should provide an ideal combination of service operations and operational research. It will have library and other facilities which it is hoped will attract those the world over who are interested in the problems of tropical meteorology. It is expected that arrangements will be made to enable the research teams of various universities to supplement or participate in research programs at the new Center, which will employ electronic computers for diagnostic studies and for the development of numerical periods of forecasting daily weather in tropical regions of the well hurricanes.

St. Lawrence Seaway

A new weather information booklet entitled "Climatology and Weather Services of the St. Lawrence Seaway and Great Lakes" has been published recently by the Weather Bureau, U. S. Department of Commerce.

This new publication provides a complete summary of weather conditions found in the Great Lakes area and contains many tables and charts depicting those meteorological and oceanographic elements considered important in the safe operation of vessels along the great waterway from Quebec to Chicago and Duluth.

The 75-page climatology booklet includes important meteorological data on storms, winds, fog, humidities, ice, water currents, extreme temperatures of air and water, and variations in lake levels.

The weather services provided along the 2,000-miles waterway by the U. S. Weather Bureau and the Canadian Meteorological Service are also described in the booklet, along with explanations of codes used in weather radio-telephone broadcasts, and a listing of broadcast schedules.

The new publication—identified as Weather Bureau Technical Paper No. 35—was prepared by the Marine Section of the Weather Bureau's Office of Climatology. It may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (price, 45 cents).

IGY Bulletin

Your editor would like to call attention to the *IGY Bulletin*, a monthly survey by the U. S. National Committee for the International Geophysical Year of the National Academy of Sciences. This excellent 16-page publication each month gives a concise summary in the language of an educated layman of four or five aspects of IGY research and activity, along with IGY bibliographic notes.

The article in the April *Weatherwise*, "IGY Special Studies in Meteorology," was re-

printed from the February *IGY Bulletin* and is an example of the concise, readable type of summary in which this publication excels.

It has recently been announced that the *IGY Bulletin* will continue publication through June 1960. Subscriptions rates are $2.00 for the 12 monthly issues. Special rates for teachers are $1.50, and $1.00 in lots of 5 or more mailed to one address. The entire series of 36 issues covering 1957–58, 1958–59, and 1959–60 can be obtained for $6.00. Please send remittances to the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C. Make checks payable to the National Academy of Sciences.

The Weatherscope

A unique outline map of North America has recently been introduced which enables students and individuals to follow visually the changing daily weather patterns. The Weatherscope contains a map of North America measuring 17 x 17½ inches, along with appropriate movable symbols to indicate highs, lows, hurricanes, thunderstorms, snowstorms, and cloudy areas. The patented symbols, which contain no adhesive, are fastened to the glossy surface of the map merely by thumb pressure and are easily removed.

In the word of the designer, "The Weatherscope gives the observer a satellite's view of the overall weather pattern; without this grand plan, the changing forces that shape the local weather appear as a jumble of unrelated phenomena. Using visual observations, newspaper, teletype, radio & TV information, the observer can plot highs and lows, fronts, etc. by sticking the right 'scopers in their proper position on the map and thus be better able to understand and anticipate the changes most likely to occur at his station." The Weatherscope, which was planned and developed by meteorologists, is a product of Planoramics, 631 East First Street, Boston 27, Mass. List price is $5.00.

Atmospheric Sciences Summer School

A total of 325 applications from high school students residing in 32 states were received for participation in the Summer Science Training Program in Atmospheric Sciences now in progress at the Loomis School, Windsor, Connecticut. The program, which is supported by the National Science Foundation, is under the direction of the American Meteorological Society. Dr. Vincent Schaefer is in charge of the instruction.

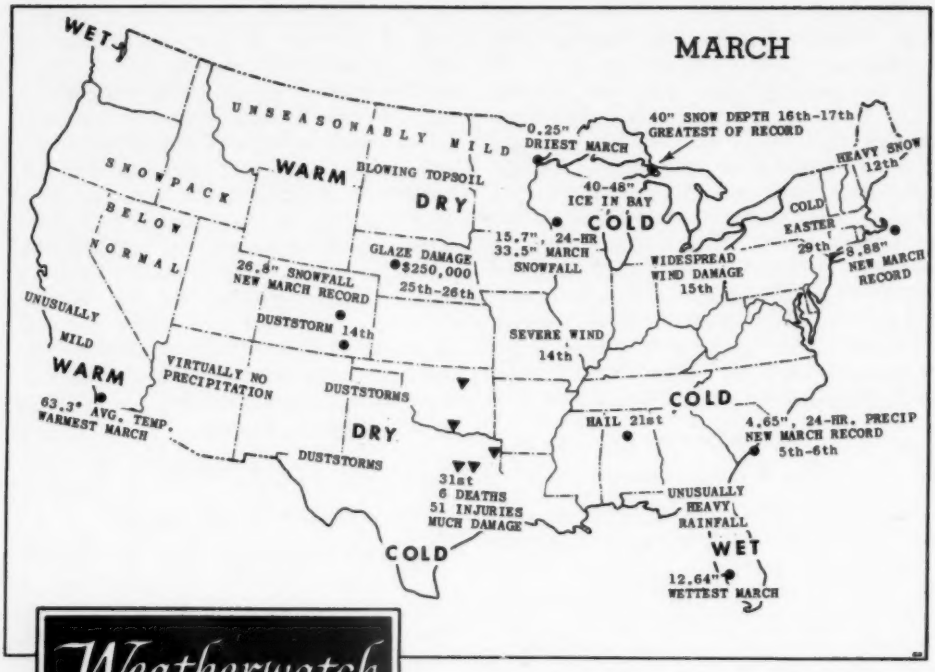
All applicants were required to have three years of mathematics and one year of physics and to have recently completed the 11th grade. Of those applying, 204 met these requirements, completed their papers, and took the qualifying tests. Thirty were finally selected from this talented group. They represent all sections of the country and include one from London, England.

Arctic Meteorology

The Arctic Meteorology Research Group of McGill University will hold a seminar in Arctic and Stratospheric Meteorology at Stanstead College, Quebec Province, from 27 July to 9 August 1959. Stanstead is located just over the U.S.-Canada border near Derby Line, Vermont. The seminar will mark the formal establishment of a department of meteorology at McGill University, Montreal. These sessions are intended primarily for professional meteorologists and students, but are open to all interested persons from the geophysical sciences, government departments, and the armed services. All inquiries should be directed to: Prof. F. K. Hare, Arctic Meterology Research Group, McGill University, Montreal, Quebec Province, Canada.

Summer AMS Activity

Summer travelers in the central part of the country can attend two interesting AMS meetings on opposite sides of the Great Plains. A meeting at Denver, Colorado, on 27–29 August will feature Weather Modification by Artificial Means, and will be held in conjunction with the American Society of Civil Engineers. Following this, a regular AMS general meeting will convene at Minneapolis, Minnesota, on 31 August to 3 September, and the chief subject on a varied agenda will be Stratospheric Meteorology.



Weatherwatch

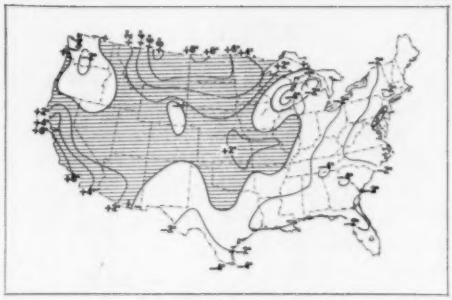
Data by Office of Climatology, USWB.

Drought Features Early Spring

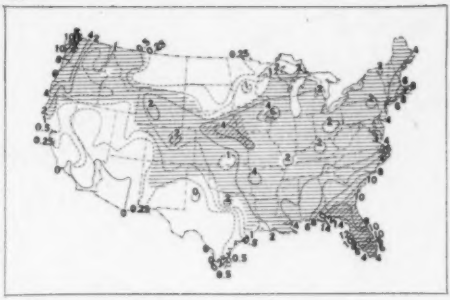
DAVID M. LUDLUM, *Editor*

March 1959 presented its usual varied weather pattern along with some meteorological tricks that one always expects this transitional month to perform. In the desert Southwest and along coastal California it was an almost summery spell with new records for persistent warmth and dearth of precipitation. In the Midwestern areas surrounding the upper Great Lakes March continued the wintry trend with below normal temperatures and three major snowstorms to extend the current severe winter season to four full months. In the Southeast the trend of February was reversed with a cool and backward first spring month. Excessive precipitation fell on the New England coast and also along the South Atlantic shore including all of Florida to put the precipitation season well ahead of schedule. Though it was a windy month in the great Mississippi Valley and on the Great Plains, severe local storms of the thunderstorm and tornado types, which one often sees in such devastating form at the time of the vernal equinox, were absent from the news headlines.

CIRCULATION—The principal feature of the upper-air circulation maps over the United States during March centered in a trough of varying breadth located over the Mississippi Valley at times or eastward over the Atlantic Coast states at others. The trough's presence shows up very well on the mean pressure maps: at the surface a minus departure from normal of 4 mb—0.12″ appears over Missouri, while near the 10,000-foot level the greatest variance from normal lies over Tennessee. Pressures east of a line from Minnesota to Arizona averaged below normal, while to the west and northwest there was a considerable excess. Here lies the key to the month's circulation—an all-pervading westerly jet flow swept in from the Pacific during most of the month and then poured southeastward over the Rockies and Plains into the broad trough covering the Eastern States. Under trough conditions with much cloud and rain, temperatures averaged well below normal in the Southeast, the reverse of February conditions when the air flow over the Gulf and South Atlantic States had been from the southwest. A second trough lay off the New England coast during part of the month, actually an extension of the main polar trough running southwestward from a vortex over southern Greenland; and this extensive trough of low pressure drew polar air masses southeastward from central Canada and pro-



Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.



Total Precipitation in inches. USWB chart.

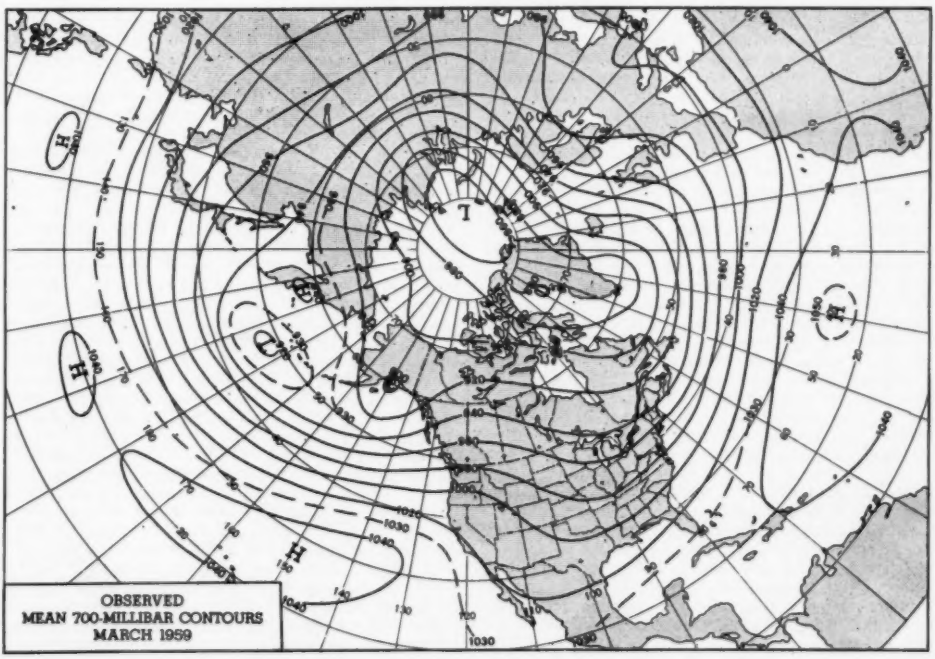
longed the winter season from the Lower Lakes eastward to northern New England.

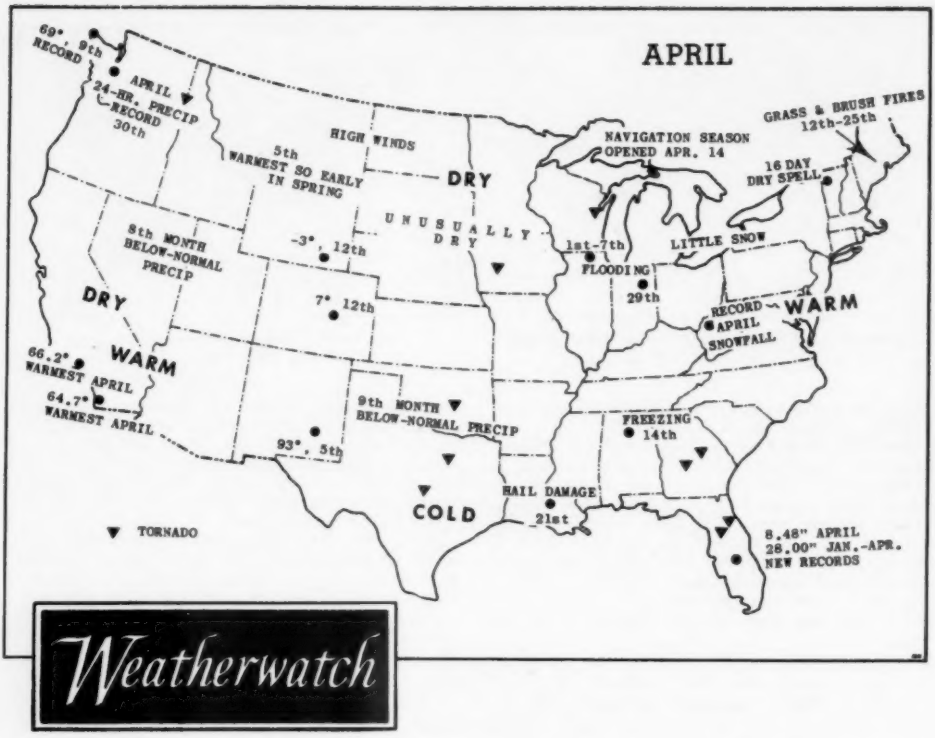
The southern end of the trough over the Mississippi River area proved an active area of cyclogenesis during March with practically all storms of the month either originating or moving close to the Texas-Oklahoma area. The three major storm assaults on the upper Midwest, on the 5–6th, 14–15th, and 26–27th, all organized their forces there before striking swiftly northeastward. There was also a tendency for less vigorous cyclones to follow a low latitude jet and move directly eastward from the cyclogenetic area, crossing the Atlantic Coast south of New Jersey; one of these gave New England its principal snowstorm of the winter on the 11–12th with near-blizzard conditions reported from central and northern sections. Other lows triggered heavy frontal rains along the South Atlantic Coast as fronts trailed far southward.

In the Far West ridge conditions prevailed most of the month as the Pacific high nudged a shoulder in over the Pacific States; its hold was unbroken from the 1st to the 17th, and then after a fluctuat-

(*Continued on page 131*)

The upper-air map below shows the pattern of air flow for March at about 10,000 feet, on which the average weather largely depends. The contours lines represent the mean height of the 700 mb. pressure level. Figures are in tens of feet: 1020 = 10,200 ft., 980 = 9,800 ft., etc. Chart by Extended Forecast Section, USWB.





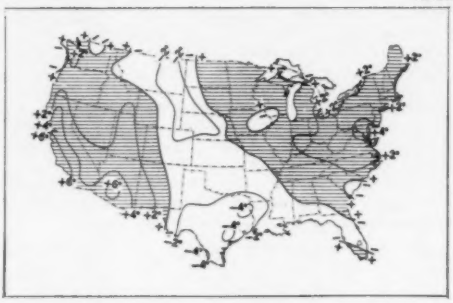
Weatherwatch

April finally broke the stronghold which Old Man Winter had so unremittently fastened on the northern United States from the Great Lakes region eastward to New England. For the first time in four months it was generally warm in all sections except for a band from Montana southeastward to include all of Texas and thence eastward across the southern tier of states to central Florida. This area also reflected the path of southeastward-moving anticyclones which featured the month's weather. Though there were several areas of heavy precipitation, it was the places which were already well-watered which received the downpours. The upper Mississippi Valley, interior Texas, and all of the Southwest suffered from an almost total lack of worthwhile precipitation. In the storm category, there were heavy April snows over the Rockies and western Plains on two occasions, but again an abnormal dearth of severe local storms except for one serious tornado outbreak over Texas and Oklahoma on the 2nd. As the month closed dust storms were filling the air over wide areas of the Plains, Rockies, and Plateau where precipitation for months had fallen far short of the expected.

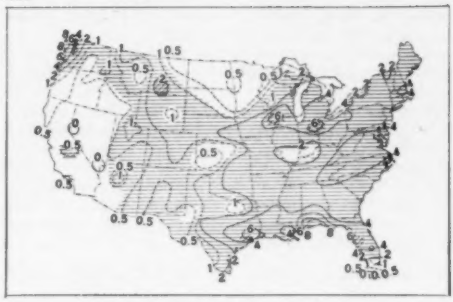
CIRCULATION—The mean upper-air circulation maps for April somewhat resemble March's pattern with a general western ridge-central trough-eastern ridge combination, though the departures from normal were of much less magnitude with resultant less severe weather conditions generated. The central trough was a broad area of low pressure across the Great Lakes and southward to Oklahoma, but without an extension into the Gulf of Mexico as the previous month featured. In fact, there was only one storm development in the Gulf during April, and a minimum of movement of Gulf air masses into the central valleys of the United States. Pressure ran above normal off both the mid-Pacific Coast and the mid-Atlantic Coast, and therein lies the key to the nation's weather pattern during April.

The Pacific ridge occupied a mean position along the 125° meridian just off the shoreline with pressure contours sloping off sharply to the west where a trough had extended southward from the Gulf of Alaska along 160° W to split the Pacific high which had occupied such a commanding position during March. The ridge over the Pacific States appeared rather flat on the mean monthly map, but on occasions it built northward to the sub-Arctic as a blocking feature, and this permitted three intrusions of frigid air masses to descend on the Rockies and Great Plains during April to recreate wintry conditions there. The hold of anticyclonic conditions on the Pacific States is well demonstrated by the rainfall pattern in central and southern California where there was only one short period on the 25–26th when measurable rain fell in the area from San Francisco to Los Angeles. As the month closed, the ridge had moved well eastward to the Rockies, and an active trough just off Washington and Oregon dropped rainfall of record intensity for April on the 29–30th. The westerly jet at low levels entered the country over Washington, sped eastward to central Montana, and then dipped southeastward into the central trough in Missouri.

The Atlantic ridge also played an important role in determining the weather pattern east of the Missis-



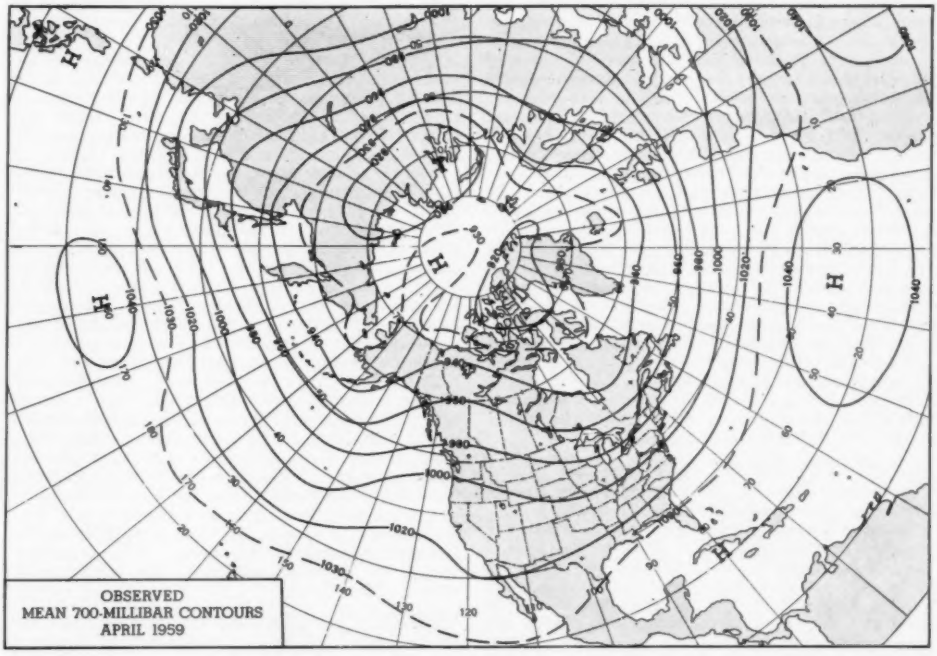
Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.



Total Precipitation in inches. USWB chart.

sippi River, and even upstream as far as the Rockies since the sluggish movement of pressure systems across the Plains and the Midwest can be attributed to the persistence of strong anticyclonic conditions over the Southeastern States and adjacent waters. Pressure averaged well above normal in the vicinity of Bermuda and eastward, with streamlines of air flow running west-east from the Mississippi River to Bermuda, reflecting the movement of several anticyclones directly eastward from Texas-Oklahoma. The high pressure over the Southeast proved very resistant to fronts seeking to move in their accustomed direction southeastward. A front in Texas on the 7th did not clear southern Florida until the 13th—one in the central Rockies on the 14th was held west of the Mississippi River until the 18th, and then did not pass Florida until the 22nd—a final front running northeastward from Nebraska to Wisconsin on the 23rd did not reach the Florida Keys until the 30th.

The month's meteorological pattern was largely one of competition between anticyclones of polar and tropical location with the tropical high over the Southeast playing the dominating role and giving way only reluctantly. The Eastern States, thus, enjoyed the return circulation of the Atlantic High and basked in a mild southwesterly flow for a pleasant spring month. The Plains States west of the Mississippi, on the other hand, were in the active forward area of polar air flow where three marked outbreaks of cold air reduced temperatures below normal and brought two snow periods. The greatest departures from normal came in the South: parts of east Texas were as much as four degrees below normal, well demonstrating that air flow there was from the northwest to the exclusion of warm air streams from



the Gulf. The absence of tropical air over Texas readily accounts for the dearth of severe local storms in their usual locale at this season.

The central trough produced little cyclonic activity as compared to the continued cyclogenesis of March in the same area. Storm centers were generally forming on semi-stationary fronts, causing some precipitation to the north of the front in areas which had already received heavy March falls. The main cyclonic movement in April came across southern Canada north of the path of the 10,000-foot jet stream flowing from a southern point in the trough in Missouri east-northeastward across the Lower Lakes and across central New England.

AN INTERESTING ANTICYCLONE—April featured anticyclonic activity with polar and tropical highs competing for control of the American weather scene. Probably the most important single anticyclone was that which moved inland from the Pacific High over Washington and British Columbia on the 6th with a central pressure of about 1032 mb—30.47″ and then remained over the southern British Columbia area for three days with a peak central pressure of 1040 mb—30.70″. It was reinforced on the 8th by an Arctic high and then moved as a broad band of high pressure to North Dakota by the 11th, thence southward to Oklahoma-Texas by the 13th; here a sharp turn to the east took place and the high drifted across the Gulf States to join the Atlantic High off Jacksonville on the 16th.

The ten-day migration from the Pacific Ocean to the Atlantic Ocean had produced a variety of weather. From a position over British Columbia on the 7th, it poured cold air into the Great Plains to rout a week of spring-like conditions there, dropping temperatures to the teens and low twenties on the 8–9th and setting some late season marks. As the cold air poured down the flank of the Rockies, it triggered very heavy snows at Denver where 11.6″ fell on the 8th and at Colorado Springs which had a three-day storm of 23.3″. As the reinforced high moved southward over the Plains on the 11th and 12th, an arm extended eastward over the Lower Lakes to hem in an active low center which had formed over the western Gulf of Mexico on the 11th as opposing air masses collided there. The cold air from the high turned rain to snow over the middle Appalachians, dropping six inches over parts of West Virginia and Pennsylvania with lesser amounts to the coast of New Jersey and threatening for a time the entire Northeast with a major mid-April snow.

As the high cell moved eastward over the Gulf States on the 14th and 15th, record minimum temperatures were set and a freeze experienced in parts of Louisiana and Mississippi. Damage was generally light since the critical temperatures persisted for only a few hours at dawn. This anticyclone, though its center passed offshore on the 15th, continued to resist the movement of a front in the mid-Mississippi Valley, and it was not until the 21st that a low pressure system occupied the Southeastern States to the exclusion of anticyclonic influences.

PRECIPITATION SITUATION—The *Weekly Weather and Crop Bulletin* reported at the end of April that precipitation remained deficient in the northern and southwestern Great Plains, in the extreme upper Mississippi Valley, and the Far Southwest. Precipitation in these areas had been less than 50 per cent to locally less than 25 per cent of normal for April and for the past five months. High winds on numerous occasions during both March and April had speeded the decline of soil moisture which was extremely short in most of these areas. Some precipitation totals for the past five months were: Phoenix, Ariz., only 0.91″; El Paso, Tex., 0.43″; Wichita Falls, Tex., 2.86″; Glasgow, Mont., 1.80″; Fargo, N. D., 1.11″; and Duluth, Minn., 2.27″. Beneficial showers fell in the central and northern Great Plains on 4 May, and the second week of May was marked by an outbreak of turbulent weather over much of the Plains and Mississippi Valley. Precipitation in the rest of the nation for the past five months generally had ranged from 75 per cent to 100 per cent of normal, although amounts ranged up to 200 per cent in Florida.

END OF WINTER IN WISCONSIN—The winter of 1958–59 closed in dramatic fashion during March in much of Wisconsin and along the shores of Lake Michigan. At many stations the winter had been the coldest since 1919–1920, and at some locations the snowiest of all-time. Muskegon, on the lee shore of Lake Michigan, set a new mark of 129.4″ of snow, well over the old record of 114″ established in the memorable winter of 1917–18. At La Crosse, Wisconsin, on the Mississippi, a new record was also set, thanks to a 33.5″ total in the month of March. Madison, Wisconsin, with a long record, had its second snowiest winter. Up north at Sault Ste. Marie the snow cover in mid-March reached an all-time record accumulation of 40″, exceeding the greatest previous depth of 36″ measured way back in January 1894. For contrast, it should be pointed out that Duluth, Minnesota, at the opposite end of Lake Superior and in the winter drought belt, had only 27.8″ of snow all winter for the second lowest amount of record!

The weatherman at Green Bay gave a rather terse summary of the winter situation there as March closed: "Good 'old fashon'd' winter weather continued in the month adding 4 more days of zero weather for a grand total of 49 for the winter, a new high. To further aggrevate conditions, the maximum of 44° was worse only twice. The record low of 39° for the maximum temperature in the month of March was set in 1899. Practically all the winter's snow was on the ground when the heavy snow storms hit on the 5th and 14th. Traffic was stopped in both. Certain country roads were not opened until three days after the storms. Less snow fell in the second storm, but with old snow on the ground, drifts up to 12 feet were common. At the month's end, frost was out of the ground while old snow banks up to 6 feet deep were still common along road ways. In nearby wooded areas average snow depth was 23 inches on the 7th and 28 inches on the 17th. Melting of the snow was very slow. Flooding from the small streams was very minor. Much ice in the Bay was up to 40 inches thick, with a few reporting 48 inches. These are greatest depths in modern times. At month's end, ice on Bay continued solid. Only the snow had turned to slush. Harbor opened on the evening of the 20th." And in his April summary: "Part of the low nighttime readings is reflected in the persistent old wintertime snow cover. Banks of old drifts were common on the 8th. These were mostly gone by the 15th. Yet a few isolated old drifts persisted to the end of the month. Vegetation has been quite slow in developing. . . . Ice in Bay was slow in clearing. Navigation opened through heavy solid ice field on the 11th. Deterioration of the ice became common following the rains on the 17th."

WINTER ELSEWHERE—Springtime in the Rockies was a bit on the snowy side this year as

two storm periods on the 7–10th and 19–20th brought deep falls. Colorado Springs witnessed a drop of 23.3″ in the first storm with 14.7″ coming in a 24-hour period. Further north Denver received 16.4″ in this storm with an 11.6″ fall on the 8th; the added April amount of 17.6″ at Denver brought the season's total at the end of April to 99.3″, the second largest in history. The only larger seasonal snowfall was 118.7″ in the winter of 1908–09. The second storm centered in Wyoming and western South Dakota: Lander, Wyoming, had a total of 16.2″ on the 18–20th, and Rapid City, South Dakota, measured 13.1″, of which 10.1″ fell in a 24-hour period for the heaviest such snow for April in the past 17 years.

The south shore locations along Lakes Erie and Ontario also approached record figures although there was practically no snowfall in the month of April. Buffalo totaled 114.5″ for the fourth consecutive winter with 100″ plus (the normal there is 76.1″). Rochester received 140.6″, just 0.9″ below the all-time record set in 1900–01 with the possibility that a May snow might put the figure higher. Though snowless in April, the seasonal fall at Syracuse reached 137.2″ close to the record of 146.9″ set in 1955–56. These three New York stations have records commencing about 1885, and the severity of the past winter and the very heavy snowfalls of the past four years have done little to convince up-Staters that their climate is changing for the better.

In the Far West it was a different story. The snow runoff forecasts of the Soil Conservation Service of 1 May 1959 reaffirmed "prospective water shortages ranging from critical to mild in portions of Nevada, California, Arizona, Utah, Oregon, Idaho, Colorado, and New Mexico, where reservoir storage is lacking. Where carryover storage is available supplies will be adequate. In northern areas of the West runoff will generally be normal or greater." Subnormal precipitation in April over much of the Plateau and Southwest, combined with snowpack much below normal, will greatly aggrevate the water situation in the summer season.

March (*Continued from page 127*)

ing period the anticyclonic regime once again established supremacy in the closing days of the month. The interaction of the northeastward extension of the Pacific high with a small, but active low center directly north in the Gulf of Alaska induced a swift westerly current over British Columbia and the Northwestern States. Pacific air masses at this time of year are usually moist in their lower levels, so the coastline received heavy precipitation and the immediate interior moderate amounts; but well inland the rainfall dropped off abruptly and near-drought conditions prevailed over much of the Plateau and northern Great Plains.

Sunny skies provided the principal highlight of the weather over the Plateau and Southwest. At Reno there was 100% possible sunshine on every day from 25 February to 16 March, the longest winter period of continuous sunshine of record and only exceeded once in summertime! At Sacramento in northern California, no rain fell, not even a trace, until the 22nd, and at Los Angeles the month was completely rainless, for the driest March of record. So strong were the ridge conditions over the Pacific States that no storm centers entered the coast south of Vancouver Island, and the few trailing fronts had little influence south of San Francisco Bay.

The persistence of ridge conditions over central and southern California with subsiding air and sunny skies again caused abnormally high average temperatures, to continue the long series of excessively warm months along the Pacific Coast from San Francisco southward. San Diego had its warmest March since records commenced in 1872. At the Weather Bureau's downtown location in Los Angeles it was the second warmest March in addition to being the driest. Further north at San Francisco the mercury averaged out the highest since March 1941 with a plus 3.3-degree excess. Inland at Sacramento the maximum temperature daily soared to 70° or more on each of the first 20 days of March, the longest string of such days ever observed so early in the season; and it was the third warmest March in the records of the California capital dating back to 1878. The absolute maximum in California occurred at Indio U. S. Date Farm when a reading of 95° on the 4th climaxed four successive days with 90°-plus.

DEVELOPING DROUGHT—A dry March following a series of months with below normal precipitation began to raise expressions of anxiety among farming interests over wide areas of the agricultural West. Aside from a belt of heavy precipitation from Colorado northeastward to the Great Lakes, reflecting the prevailing March storm track, rainfall west of the Mississippi River fell much below normal with the single exception of the far Northwest where maritime circulation provided adequate moisture.

Along the northern border the rainfall deficiency increased rapidly as one progressed eastward as the already desiccated Pacific air was further dried as it descended as a foehn wind from the crests of the Continental Divide. In Montana, Helena with 0.02″ had its driest March since 1881, and Havre's 0.08″ catch was the smallest there since 1887. Further east Devil's Lake, North Dakota, added only 0.12″, tying for the second driest March, and increasing the total precipitation for the five months to only 0.45″. Minneapolis, just north of the heavy snow belt of March, reported its seventh consecutive dry month to increase foreboding for the spring wheat and grass crops in its hinterland.

South of the heavy precipitation belt the growing dryness was becoming a matter of concern on the High Plains of Texas and Oklahoma. At Amarillo March produced only 0.26″, climaxing the driest eight-months period, August through March, which has ever been experienced in the 67-year record at that station. The 1958–59 eight-month total has been 5.21″ compared with a normal of 11.05″. It was also dry eastward where Wichita Falls on the Arkansas border had its eighth consecutive month with below normal precipitation—southward at Brownsville on the Mexican border only 0.60″ fell at that often very wet spot—and westward into New Mexico Roswell parched with a March total of only 0.03″.

California and the interior of the Southwest also had a dry time in March as ridge conditions produced clear skies and subsiding air. Los Angeles had no rain at all for its driest March of record. At San Diego only a trace fell, a mark which was exceeded only twice before by completely rainless Marches. In the Great Valley Bakersfield totaled 0.02″, and Sacramento had no measurable rain until the 22nd. At Mt. Shasta City in the north where March 1958 brought very heavy snowstorms all month, not a flake fell until the 22nd to reduce the snow pack at the 8,000-foot level to 103″, or 28″ below normal and 81″ under the mark of a year ago.

MIDWEST SNOWSTORM—A severe early March storm with high winds and heavy snow struck parts of the upper Mississippi Valley and the upper Lakes region on the 5–6th to continue the hard winter conditions which had already made the season noteworthy in weather annals. A low pressure center, developing in southwestern Texas and moving almost north-northeastward up the Mississippi Valley, slowed its pace somewhat in crossing Missouri and Illinois to give the area to the west of the track a rather prolonged period of precipitation, resulting in abnormally heavy accumulations under sub-freezing conditions. The storm path moved close to Columbia (Missouri), Quincy and Elgin (Illinois), and Muskegon and Alpena (Michigan), and then into Ontario. A low pressure of 28.95″—981 mb at Muskegon early on the 6th indicates the severity of the storm as it crossed southern Lake Michigan.

The area of very heavy snow reached from extreme eastern Nebraska northeastward across Iowa and Wisconsin to eastern Lake Superior and northern Lake Huron, including southeastern Minnesota and northwestern Illinois. Chicago had mostly rain in this storm, but temperatures were just below 30° about 75 to 150 miles west of the storm track and there heavy snow fell with amounts close to 15″ in the area where Iowa, Minnesota, Wisconsin, and Illinois are in close proximity. The industrial city of La Crosse, in southwestern Wisconsin on the Mississippi River, was in the apex of the heaviest snow area, receiving a total fall of 18.5″ which completely tied up the city. Snow commenced at 0600 on the 5th and continued for 34 hours until 1600 of the 6th, with the heaviest fall taking place on the afternoon of the 5th when the storm center was about 180 miles directly south on the Iowa-Missouri border. The storm total raised the accumulation on the ground at La Crosse to 31″, and snow depths through central Wisconsin were in the same range.

The northeast winds accompanying the storm and the following blow from the northwest caused severe drifting over most of Wisconsin and northern Michigan to put this storm well up in the lists of memorable March snows. In northern Wisconsin and upper Michigan it topped all records at Escanaba for a 24-hour March snowfall since the year 1916. At Marquette it was judged the worst March storm since 1939. It is interesting to note the sharp delineation of the snowfall pattern in a rather narrow band of 150 to 175 miles breadth: Minneapolis, only 130 miles northwest of La Crosse, received only 0.9″—Peoria, 100 miles southeast of the heavy snow area around Dubuque, had only 0.8″.

A second severe March storm on the 15th hit much of the same areas of Iowa, Wisconsin, and Michigan which had felt the brunt of the snow and wind on the 5–6th. A developing low moved across southern Kansas on the 14th and then headed northeastward, moving on a Kansas City-Chicago-Alpena axis close to the path of the earlier storm. This one proved a faster moving affair; though precipitation was lighter, the accompanying gale force winds caused troublesome drifting to again tie up road, rail, and air traffic. Most of the area received a new six-inch covering, but amounts increased up to 15″ in northern Michigan where ground accumulations exceeded 50″ at the conclusion of the storm. As the center sped northeastward across Michigan and Lake Huron on the 15th, gale winds with hurricane force blasts swept the Lower Lakes and Ohio Valley states doing widespread minor damage, such as downing trees, smashing store windows, and twisting TV antennas. Damage estimates ran close to $1 million in Ohio alone.

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Unusual Phenomena in Illinois

DURING the evening of 2 April residents of a rural area near Leland, Illinois, were startled by a brilliant flash of light during a thunderstorm. The flash was reportedly observed by a motorist 15 miles away at the time. In the area near Leland the unusually brilliant flash was followed almost immediately by what was described as a sound like an explosion which shook nearby houses. At one house four windows were broken, flower pots knocked down, and loose objects scattered about. Residents of this home assumed that it was struck by lightning, but no evidence of any direct lightning action could be found on the house or in the vicinity.

Several days later Burton Benson found a large hole in the ground in the middle of an 80 acre corn field. It is believed by residents that the hole was probably caused by an unusually severe stroke of lightning. The hole was irregular in shape, from 7 to 12 feet in diameter, and a foot or more in depth. Digging failed to disclose any external object which might have caused the hole. The house which suffered the damage was three-quarters of a mile from the hole, and closer farm buildings showed no apparent damage. The accompanying photograph was supplied by Don Hartley and James Knight of Sandwich, Illinois, and forwarded to *Weatherwise* by Ivan Brunk of the Chicago Weather Bureau.

Project Skyfire

A cooperative study of lightning-caused forest fires has been conducted in the Missoula (Mont.) area for several years by the U. S. Forest Service with the aid of the Weather Bureau and other agencies, public and private. Last Summer in Project Skyfire silver iodide generators on the ground were used in cloud-seeding experiments. This Summer silver iodide will be distributed from airplanes directly into the cloud bases. Scientists there will also examine thunderheads by radar and place electric field meters on the ground in the usual cloud paths. Experimental models of a simple lightning-stroke counter also will tested.

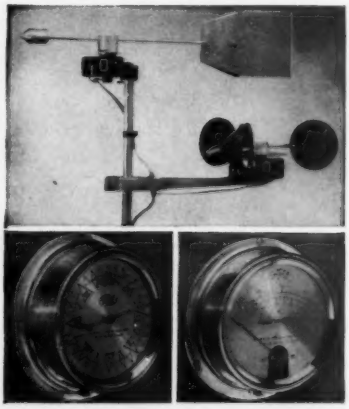
The basic research is directed at finding out what makes thunderstorms grow, and how they generate and release their lightning charges from cloud to cloud and from cloud to ground.

"So far, we feel that under certain conditions we can modify the form of a cloud and its electric field," said DeVer Colson, Weather Bureau research meteorologist on the project, "but we are not sure yet whether we have actually averted lightning. We want to make certain that we are not increasing lightning from a given storm, or creating trouble elsewhere by upsetting the atmospheric balance. A lot more field work and careful evaluation have to be done."

By feeding silver iodide or dry ice into a cloud base, it may be possible to "snip potential storms off at the top"—that is, to keep them from building up. It may also be possible by some means to decrease lightning, or to increase the amount of rain reaching the ground.

Eastern thunderstorms are usually accompanied by heavy rains that put out any forest fires caused by the lightning. In the Far West, however, rain released from a high cloud may disappear in the dry air and never reach the ground. It is the "dry lightning" storms that cause so much damage to commercial forests and playgrounds.

In the Northern Rocky Mountain states, 70 percent of all fires is caused by lightning. The proportion also is high in Arizona and New Mexico. California and Alaska also suffer heavily from such lightning-induced fires.



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